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UGV Interoperability Profile (IOP) – Overarching Profile JAUS Profiling Rules Version 0



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1 Scope

1.1 Purpose

This document is a normative attachment to the UGV Interoperability Profile (IOP) Overarching Profile and provides specific rules and requirements associated with the profiling of the SAE JAUS message set to achieve system level and platform level interoperability. SAE ARP6012, JAUS Compliance and Interoperability Policy, prescribes guidance and considerations for the profiling of the JAUS message set in order to achieve interoperability at various levels within a JAUS System. Specific recommendations include the specification of interoperability templates, specifying a common set of standards as well as interoperability profiles that specify additional constraints necessary to create interoperable systems. These constraints may be specified as options unique to each individual selected standard, such as service definitions, timing requirements, quality of service, communication protocols, etc.

This document identifies these additional profiling constraints with respect to the SAE JAUS mes
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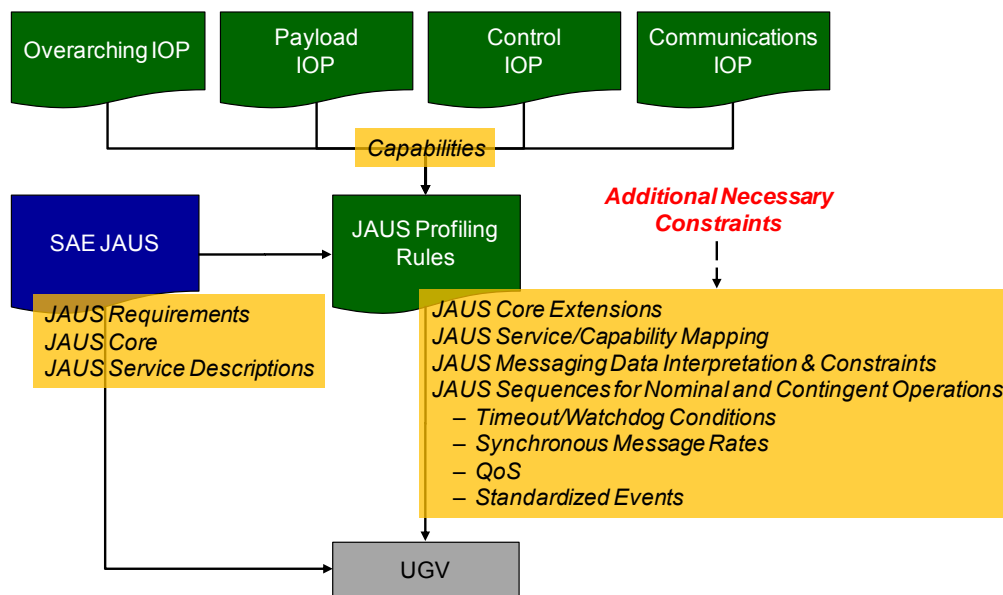


Figure 1.1-1 JAUS Profiling/IOP Relationship

IOP requirements and capabilities (functionality sets) are defined within the other IOP documents. This *JAUS Profiling Rules* document then specifies additional information, as required to affect an interoperability contract between controller(s) and UGV(s). Additional information (profiling constraints) addressed to meet IOP interoperability includes, but is not limited to:

- Clarification of data consistency, as required, for specified messages (e.g., interpretation, constraints, precision, accuracy).
- Specification of contracts for service/capability mapping (e.g., primitive, vector, velocity state, waypoint drivers).
- Specification of watchdog/timeout conditions and contingencies; especially for safety critical functions (e.g., Heartbeats, Teleop, Video, Comms, Weapons Control, SL/V).

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- Specification of synchronous message rates.

2 Source Documents

2.1 *Government Documents*

| | |
|----------|--|
| TR8350.2 | Department of Defense World Geodetic System 1984, Its Definition and Relationships with Local Geodetic Systems |
|----------|--|

2.2 *Non-Government Documents*

| | |
|----------|---|
| AIR5665A | SAE Aerospace Information Report, Architecture Framework for Unmanned Systems (AFUS), April 2009. |
| ARP 6012 | SAE Aerospace Recommended Practice, JAUS Compliance and Interoperability Policy, April 2009. |
| AS5669A | SAE Aerospace Standard, JAUS/SDP Transport Specification, February 2009. |
| AS5684 | SAE Aerospace Standard, JAUS Service Interface Definition Language, December 2008. |
| AS5710 | SAE Aerospace Standard, JAUS Core Service Set, December 2008. |
| AS6009 | SAE Aerospace Standard, JAUS Mobility Service Set, April 2009. |
| AS6057 | SAE Aerospace Standard, JAUS Manipulator Service Set. |
| AS6040 | SAE Aerospace Standard, JAUS HMI Service Set. |
| AS6060 | SAE Aerospace Standard, JAUS Environment Sensing Service Set. |
| AS6091 | SAE Aerospace Standard (draft 0.5), JAUS UGV Service Set |

3 Key Concepts and Information

This section provides information on key document concepts, how to use this document to describe interoperability requirements, definitions, and other information.

3.1 Definitions

| Term | Definition |
|----------------------------|--|
| Capability | A capability is a single operationally relevant function - for example, teleoperation would be a capability that provides the function of allowing a user to drive a vehicle non-line of sight using a camera. |
| Complex Payload | A complex payload is a payload that aggregates multiple capabilities. The definition of logical payload in this document extends from the Payload IOP document to define a complex payload as either a physical or <i>logical</i> aggregation. A complex payload shall always be represented by a JAUS node. |
| IP Address Assignment List | The IP Address Assignment List is a list of IP addresses with associated JAUS IDs that are located at those IP addresses. For example, an IP Address Assignment List might have three IP addresses, with one JAUS ID associated with IP address #1, 2 JAUS IDs associated with IP address #2, and 1 JAUS ID associated with IP address #3. The IP Address Assignment List is used by Transport Layer Routing elements to properly route messages and other communications to the correct transport layer endpoint given a logical JAUS ID. |
| JAUS Component | A JAUS component is a logical grouping of services. Each component aggregates services to provide a single operationally relevant capability. The component offers a service interface to other consuming components to use. For example, teleoperation could be a component that aggregates a primitive driver service and some sensor services to provide teleoperation capabilities to a robotic controller. |
| JAUS Node | A JAUS Node is logical grouping of components within a subsystem. Within this IOP, nodes are specified to aggregate related capabilities. This aggregation may be either logical (i.e. any capability that affects platform motion is aggregated under the Mobility node) or physical (i.e. a manipulator payload with two cameras and a sensor on it are considered a node). |
| JAUS Service | JAUS services represent the lowest level of the topology. For the purposes of this IOP, services provide an abstraction to hardware or software algorithms that reside on the platform. Services may be internalized within a component or may be provided via an interface that is consumed by components. |
| JAUS Subsystem | A JAUS subsystem is an independent and distinct unit within a system. Subsystems include robotic controllers, robotic platforms, and video terminals connected and communicating via a specified set of interoperability attributes. A subsystem contains one or more nodes. |
| JAUS System | A JAUS system is the top level element within the topology and can encompass all interoperable elements (robotic controllers and robotic platforms). The system contains multiple subsystems. |

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| Transport Layer Routing Element | A Transport Layer Routing element is an element responsible for routing JAUS messages to the proper endpoint(s) on the transport layer, given a logical JAUS ID. Historically, the term “Node Manager” has often been used for the element providing this capability. |
|---------------------------------|---|

3.2 *Organization of Profiling Rules Section*

Section 4 Profiling Rules is organized into sections for each attribute/attribute option group. The groups are:

- Core
- Platform
- Mobility
- Sensor and Emitter
- Actuator and Manipulator
- Communications
- Global

Attributes are found first in each section, followed by non-global attribute options (attribute options that are only valid for values in a single group). The Global section contains attributes and attribute options that are valid for values in more than one attribute group.

Attribute sections may be broken into subsections for each value of that attribute. If there is only one value for an attribute (the default value), then the value subsections are omitted. Most value sections provide at least three subsections: Component and Service Requirements, Notes and Interpretations, and Periodicity. These subsections define the components and services provided by the attribute, any notes and message interpretations, and periodicity requirements, respectively. Some attribute sections are simplified and do not have these subsections, and some have subsections other than these three.

3.3 *Key Concepts*

3.3.1 *Interoperability Attributes, Attribute Options, and Parameters*

This document specifies Interoperability Attributes, Attribute Options, and Parameters. Interoperability Attributes profile the use of JAUS services and messages necessary to provide stand-alone capabilities or meet mandatory IOP requirements. Interoperability Attributes are organized into sets based on commonality, such as the Mobility Interoperability Attribute group containing all attributes that profile mobility related capabilities and requirements. Interoperability Attributes each have at least one value associated with them. An Attribute Value is a value that is assigned to that attribute when selecting it that impacts how that attribute functions. Interoperability Attributes may have a single Value, multiple Values that are mutually exclusive, or multiple Values that may have multiple selections made out of them. Table 3.3-1 shows the meaning of Values common across many Interoperability Attributes. Interoperability Attributes are written short hand in the form AttributeGroup::Attribute::Value. For example, the default (and only) value of the Teleoperation Interoperability Attribute is represented in short form as Mobility::Teleoperation::Default.

Table 3.3-1: Common Attribute Values

| Attribute Value | Description |
|-----------------|---|
| Default | This is the attribute Value used in most cases for Interoperability |

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| | Attributes that have only a single Value. The short form AttributeGroup::Attribute::Default may be shortened even further to AttributeGroup::Attribute in this case. |
|--|--|

Interoperability Attributes also have modifiers listed next to them in the form of [Modifier1, Modifier2, ...]. Modifiers specify how the attribute can or must be used. The following modifiers are defined:

Table 3.3-2: Attribute Modifiers

| Attribute Modifier | Description |
|---------------------------|--|
| Mandatory | This modifier indicates that the Interoperability Attribute must be chosen if the conditions in its description are met. Mandatory Interoperability Attributes are often related to core platform capabilities or safety. |
| Mutually Exclusive | This modifier indicates that only one Value from an Interoperability Attribute that has multiple Values may be chosen. For example, you cannot use dynamic IP based assignment and static assignment values for the ID Assignment Interoperability Attribute. |
| Selectable | This is a modifier used for non-mandatory Interoperability Attributes with only one Value. This indicates that the Interoperability Attribute can be selected, but does not have to be. |
| Multiple | This modifier indicates multiple instances of the Interoperability Attribute can be specified, using any valid Value. For example, if there are two basic arms on a platform, two Basic Manipulator Interoperability Attributes can be specified. |
| Composed | This indicates that the Interoperability Attribute is composed of at least one Interoperability Attribute and/or Attribute Options. Composed Attributes are the only attributes that can have other attributes added to them – in this case, all of the added attribute's services are added to the composed attribute, and all notes and interpretations still apply unless they pertain to the specific location of services or use of a particular component. |
| Aggregator | An Interoperability Attribute with the aggregator modifier aggregates one or more Interoperability Attributes together. An aggregator attribute must define a JAUS node on which components provided by other Interoperability Attributes can be aggregated. Only attributes that provide a JAUS component can be aggregated using an aggregator attribute. |

Attribute Options are additional capabilities that can be added to Interoperability Attributes. Attribute Options must be added to a valid Attribute Value – not all Attribute Options can be specified for a given Interoperability Attribute. An example of an Attribute Options is:

- Adding velocity state reporting to a mobility driver.

Parameters are items found under certain Attribute Values that must have a value assigned to them. Typically, default or recommended values will be provided. Parameters are intended to

be used to add additional detail required by certain Interoperability Attributes, such as specifying how long before a drive timeout occurs. Parameters are marked in this document by a preceding “[Parameter]” statement, followed by the parameter name and a default value in parenthesis. For example, “[Parameter] Drive Timeout (Default = 1 second)” defines a parameter called Drive Timeout with a default value of 1 second.

3.3.2 Meaning and Usage of Composed Attributes

A Composed Attribute is an Interoperability Attribute that is composed of multiple existing Interoperability Attributes and Attribute Options. All Composed Attributes must provide at least the following two parameters:

- **[Parameter]** Attribute List (Default = none) – list of Interoperability Attributes that make up this composed attribute.
- **[Parameter]** Attribute Option List (Default = none) – list of Attribute Options added to this composed attribute.

A Composed Attribute is very similar to the standard method of adding Attribute Options to a valid Attribute Value, with the following differences:

- Only a Composed Attribute can have Interoperability Attributes added to it in addition to Attribute Options.
- A Composed Attribute may add Interoperability Attributes based on the restrictions specified in the section for the composed attribute.

When an Interoperability Attribute is added to a Composed Attribute, its services are added to the JAUS component provided by the Composed Attribute, and the same message interpretations and notes still apply, but any text specifying the location of JAUS services or specific JAUS components provided are overridden by the Composed Attribute. Any service duplicated between attributes/components shall be presented as a single instance of that JAUS service.

3.3.3 Meaning and Usage of the Node Interoperability Attribute

The “Node” Interoperability Attribute is an Interoperability Attribute defined in 4.7.1 Node Interoperability Attribute [Selectable, Multiple, Aggregator]. The Node Interoperability Attribute is used to specify a JAUS node, which groups related JAUS components together. This applies to an actual platform by grouping together related sets of capabilities, either logically (i.e. grouping all positioning sensors on the platform onto a JAUS node) or physically (i.e. a physical complex payload that provides advanced navigation capabilities). There are currently two JAUS nodes already explicitly defined by this document – Mobility and Platform. Many Interoperability Attributes add to these nodes, and do not need to be grouped using a Node Interoperability Attribute. Interoperability Attributes not explicitly specified to fall under the Mobility or Platform JAUS nodes may still be aggregated on those nodes by specifying a Node Interoperability Attribute with the name of either “Mobility” or “Platform” – in this case, those Interoperability Attributes would be added to the already defined Mobility or Platform JAUS nodes. Since multiple JAUS nodes may be defined, they can be distinguished by referencing them by their name parameter, such as Global::Node::Default(“Autonomy Payload”).

3.3.4 Meaning and Usage of the Capability Interoperability Attribute

The “Capability” Interoperability Attribute is an attribute defined in 4.7.2 Capability Interoperability Attribute [Selectable, Multiple, Composed]. It is a Composed Attribute that can be selected and used multiple times, and is used to define a capability that is not explicitly provided by any single other Interoperability Attribute. The Capability attribute allows a user of this document to aggregate services from other Interoperability Attributes and Attribute Options

onto a user named and user defined JAUS component. Without this capability, only attributes that define JAUS components with specific purposes (like the JAUS components provided for Core Mobility or any of the sensors, actuators, and emitters) could have Attribute Options added to them. An example of usage of the Capability Interoperability Attribute is:

A user of this document has a requirement for a camera that has an integrated capability to provide range estimates based on structure from motion algorithms and drive to local waypoints identified in the images collected by the camera. The user wants this capability represented by a clearly specified composed attribute providing its own component. The user specifies a Capability Interoperability Attribute with a name of "Smart Camera", an Attribute List of Mobility::Basic Navigation::Local, and an Attribute Option List of Sensors and Emitters::Digital Video::Default, Sensors and Emitters::Range Finder::Default.

Since multiple Capability Interoperability Attributes can be defined, they can be distinguished by referencing them by their name parameter, such as Global::Capability::Default("Situational Awareness").

3.3.5 Example of Using this Document to Specify Requirements for an Interoperable System

This section provides a concrete example of how a user of this document could specify the requirements for an actual platform using Interoperability Attributes and Attribute Options. This section utilizes Section 5 Appendix A – Interoperability Attributes, Attribute Options, and Parameter Listing. To start, we consider the following simple set of requirements that the user has for a platform (see Figure 3.3-1: Visual Depiction of Simple Platform Requirement) and an add-on autonomy payload:

- The Platform shall provide a Teleoperation capability utilizing a forward drive camera to provide video feedback.
- The Platform shall have a driving light that illuminates the field of view of the drive camera.
- The Platform shall provide a platform manager to allow for discovery of capabilities and provide platform information.
- The autonomy payload shall provide GPS data.
- The autonomy payload shall provide a Pan-Tilt-Zoom digital camera.
- The autonomy payload shall provide a range finder and the ability to get data from that range finder.
- The autonomy payload shall provide the ability to navigate using waypoints.

Unclassified

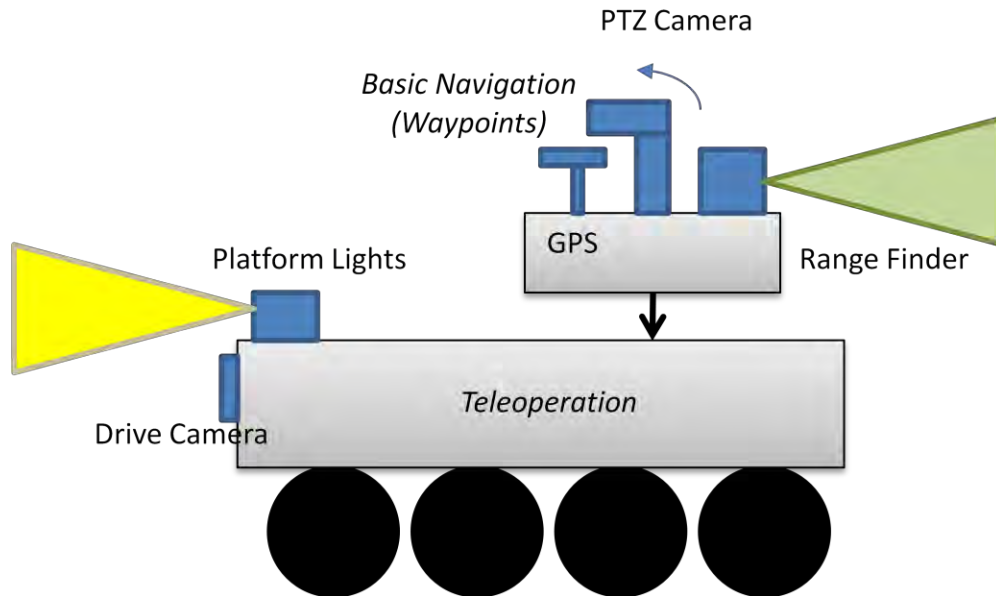


Figure 3.3-1: Visual Depiction of Simple Platform Requirement

First, we will define the platform requirements using this document. The platform is a basic mobility platform that must provide teleoperation capability, platform management capabilities, and driving lights. We will assume static assignment of JAUS IDs and use of the JUDP transport (the “JAUS ID Assignment” Interoperability Attribute selects the Value of “Static” and the “Transport” Interoperability Attribute selects the Value of “JUDP”). We begin by including the mandatory Core Attributes defined in 4.1 Core Interoperability Attributes and Attribute Options:

- Core::Core Services::Default
- Core::Access Control::Default
- Core::ID Assignment::Static
- Core::Transport::JUDP
- Core::Component Liveness::Default

Next, we add the basic platform manager defined in 4.2.1.1 Basic Platform Management Value. The basic platform manager will define our Platform JAUS node.

- Platform::PlatformManager::Basic Platform Manager

Now, we add our mobility requirements defined in 4.3 Mobility Interoperability Attributes and Attribute Options. There are Mandatory Interoperability Attributes that must be included that require the definition of Parameter values, so those are included here as well.

- Mobility::Core Mobility Component::Default
- Mobility::Drive Timeout::Default
 - [Parameter] Drive Timeout time = 1 second
 - [Parameter] Drive Frequency = 10 Hz
 - [Parameter] Drive Recovery Time = 5 seconds
- Mobility::Teleoperation::Default

Unclassified

Now, we need to specify our lights. Since our lights will be associated with the platform itself and not some particular payload, we use the "Lights" Interoperability Attribute defined in 4.4.7 Lights Interoperability Attribute [Selectable], which automatically adds a component for lights to the Platform JAUS node.

- Sensors and Emitters::Lights::Default

We have defined the requirements for our platform using IOP Interoperability Attributes and can now move onto defining the requirements for the autonomy payload we are adding. We will treat this as a complex payload and will thus define a new JAUS node for it by using the "Node" Interoperability Attribute defined in 4.7.1 Node Interoperability Attribute [Selectable, Multiple, Aggregator]. We will fill out the parameter "Aggregated Attributes" later.

- Global::Node::Default
 - [Parameter] Name = "Autonomy Payload"
 - [Parameter] ID = None
 - [Parameter] Aggregated Attributes = *TBD*

We now want to add our requirement for the GPS, PTZ camera, and range finder. We will represent this as a single "Situational Awareness" capability using the "Capability" Interoperability Attribute defined in 4.7.2 Capability Interoperability Attribute [Selectable, Multiple, Composed]. Notice that the short form for specifying a parameter list is used for the "Pan Tilt Video Sensor" Interoperability Attribute.

- Global::Capability::Default
 - [Parameter] Name = "Situational Awareness"
 - [Parameter] Attribute List = Sensors and Emitters::Pan Tilt Video Sensor::Default(*Composition=Actuators and Manipulators::Basic Pan Tilt Manipulator::Default, Sensors and Emitters::Digital Video Sensor::Default*)
 - [Parameter] Attribute Options List = Global::Global Pose and Attitude::Default, Global::Range Finder::Default

Finally, we add the requirements for basic waypoint navigation defined in 4.3.6 Basic Navigation (BN) Interoperability Attribute [Selectable, Multiple]. We want to utilize both global waypoint navigation (using the GPS) and local waypoint navigation (utilizing the PTZ camera).

- Mobility::Basic Navigation::Global
- Mobility::Basic Navigation::Local

We can now finish filling out our "Node" Interoperability Attribute and complete our specification of requirements using this document.

- Global::Node::Default
 - [Parameter] Name = "Autonomy Payload"
 - [Parameter] ID = None
 - [Parameter] Aggregated Attributes = Mobility::Basic Navigation::Global, Mobility::Basic Navigation::Local, Global::Capability::Default("Situational Awareness")

We have now completed specifying our platform and payload using this document. Our final JAUS hierarchy looks like:

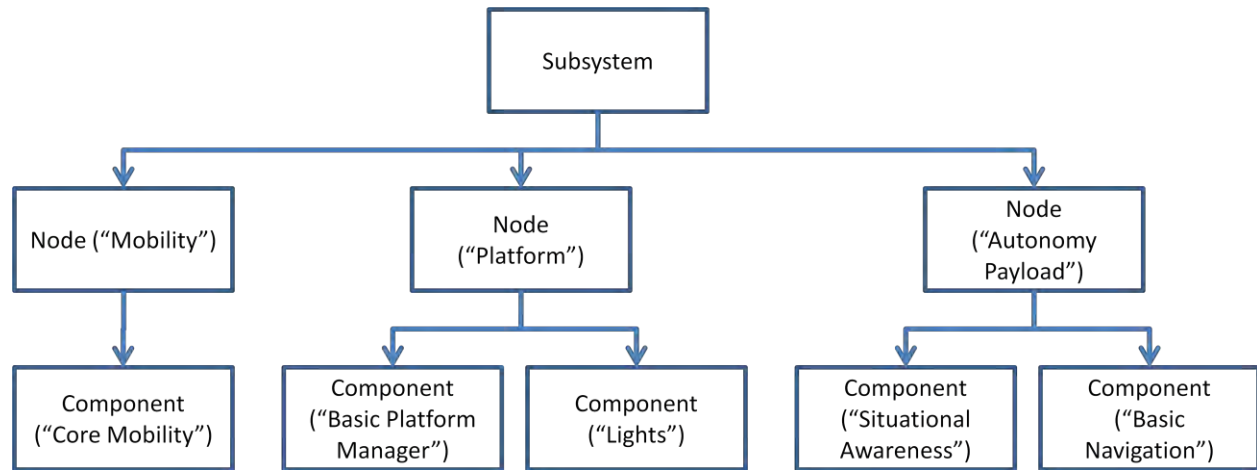


Figure 3.3-2: JAUS Hierarchy for Profiled Requirements

4 Profiling Rules

This section specifies profiling rules associated with the implementation of capabilities identified within the UGV IOP Overarching Profile, the UGV IOP Communications Profile, and the UGV IOP Payload Profile.

Profiling rules specify how JAUS services and messages are used in accomplishing the capabilities required of the IOP.

4.1 Core Interoperability Attributes and Attribute Options

The Core Interoperability Attributes are mandatory attributes that must be specified for every IOP compliant system. Core Interoperability Attributes and Attribute Options are members of the Core attribute group. The Core attributes include:

Table 4.1-1: Core Attributes

| Attribute Name | Attribute Values | Description |
|---|------------------|--|
| Core Services [Mandatory] | Default | Specifies which JAUS core services are required and any clarifications on their use. |
| Access Control [Mandatory] | Default | Defines rules for using JAUS Access Control service authority codes and Access Control Timeout. |
| ID Assignment [Mandatory, Mutually Exclusive] | Static | Uses static assignment of JAUS addresses for Nodes and Components. |
| | Centralized | Uses a centralized, DHCP like method for assignment of JAUS addresses for Nodes and Components. |
| | IP Based | Defines a method for assigning JAUS addresses based on unique IP addresses. |
| Transport [Mandatory] | JUDP | Specifies that the JAUS over UDP transport is used as specified in AS5669A JAUS/SDP Transport Specification. |
| | JTCP | Specifies that the JAUS over TCP transport is used as specified in AS5669A JAUS/SDP Transport Specification. |
| | Custom | Specifies that a custom transport is used. |

Unclassified

| | | |
|--------------------------------|---------|---|
| Component Liveness [Mandatory] | Default | Specifies how the urn:jaus:jss:core:Liveness service is used to maintain liveness to a component. |
|--------------------------------|---------|---|

4.1.1 Core Services Interoperability Attribute [Mandatory]

Each component shall provide all required core services. The required core services for each service are defined in the appropriate SAE document for each core service.

4.1.1.1 Component and Service Requirements

Core services shall be provided by every JAUS Component, based on the inheritance defined in the appropriate SAE JAUS document for every service on that Component. The following core services are profiled by this Interoperability Attribute – Liveness, Discovery, and Access Control are profiled elsewhere.

Table 4.1-2: Component and Service Requirements

| Components Providing Core Services | |
|------------------------------------|------------------------------|
| Service | Reference |
| urn:jaus:jss:core:Transport, v1.0 | AS5710 JAUS Core Service Set |
| urn:jaus:jss:core:Events, v1.0 | AS5710 JAUS Core Service Set |
| urn:jaus:jss:core:Management, v1.0 | AS5710 JAUS Core Service Set |

4.1.1.2 Notes and Interpretations

There are no special notes or interpretations.

4.1.1.3 Periodicity

There are no special periodicity requirements for the Core Services Interoperability Attribute.

4.1.2 Access Control Interoperability Attribute [Mandatory]

The Access Control Interoperability Attribute profiles the way to manage access to JAUS Components using the JAUS urn:jaus:jss:core:AccessControl service.

4.1.2.1 Component and Service Requirements

The Access Control Interoperability Attribute applies to any Component that provides the urn:jaus:jss:core:AccessControl service.

Table 4.1-3: Component and Service Requirements

| Component Providing urn:jaus:jss:core:AccessControl Service | |
|---|------------------------------|
| Service | Reference |
| urn:jaus:jss:core:AccessControl, v1.0 | AS5710 JAUS Core Service Set |

4.1.2.2 Notes and Interpretations

4.1.2.2.1 Authority Code Organization

Although JAUS defines a range of authority codes, there are no recommended practices for using them. The following table defines authority code ranges and their roles and description.

Table 4.1-4: Authority Code Roles and Descriptions

| Role | Auth Code Range | Description/Caveats |
|-------------------------|-----------------|--|
| OWNER | 255 | "root" user concept, analogous to the root user of an OS. |
| PRIMARY_OPERATOR | 205-254 | Only client role with mobility control. Can control/monitor any Component on the platform. |
| ONBOARD_MOBILITY_DEVICE | 155-204 | Only onboard controller role with mobility control. Can control/monitor any Component on the platform. |
| OPERATOR | 75-124 | Client role that can control/monitor any Component on the platform except those contained under the Mobility Node. |
| ONBOARD_DEVICE | 25-74 | Onboard controller role that can control/monitor any Component on the platform except those defined under the Mobility Node. |
| MONITOR | 0 | Can only monitor Components. |

Authority codes in a higher authority code range can pre-empt those in a lower authority code range. Control shall only be granted to a client with an authority greater than 0. Figure 4.1-1 shows a sequence diagram that illustrates the OWNER pre-emption use cases.

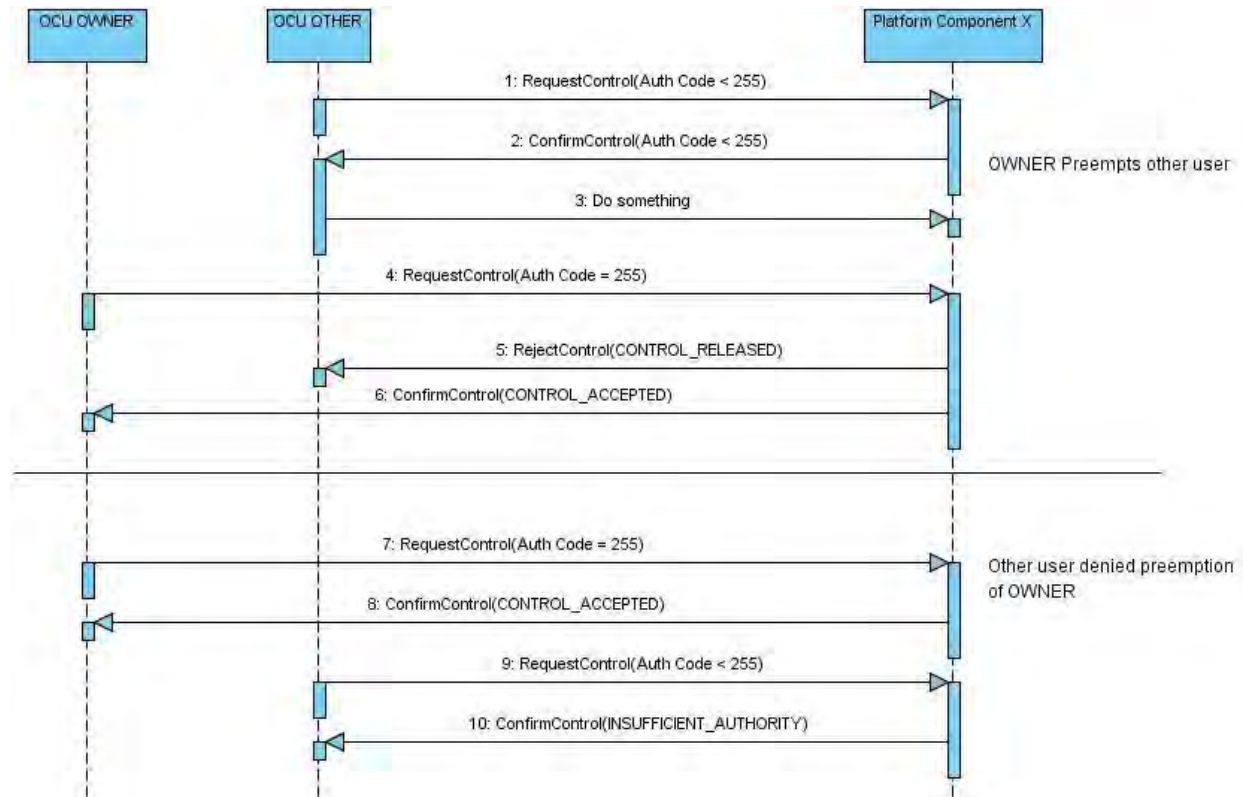


Figure 4.1-1 Owner Pre-emption Use Case

4.1.2.2.2 *Mutually Exclusive Access Control*

This document currently defines Interoperability Attributes for several different mobility JAUS Components where each components' services may want control of a platform's low level mobility controller (i.e. motor drivers). A platform that has multiple mobility JAUS components could have one of two things happen: either a single client could send messages to more than one mobility component, or two clients could send messages to two separate mobility components. In either case, how the platform responds is unknown. This problem is solved by meeting the following requirements:

1. There shall be a single ("singleton") JAUS component (the Core Mobility Component) that contains all possible services for controlling core platform mobility. This shall be the only component whose services access the low level mobility functionality of a platform. This Core Mobility Component is composed by specifying which Mobility Interoperability Attributes are used for core platform mobility control – any duplicated services shall be presented as a single service. For example, if the Core Mobility Component is composed of the RC and Teleop, it will look like the figure below.

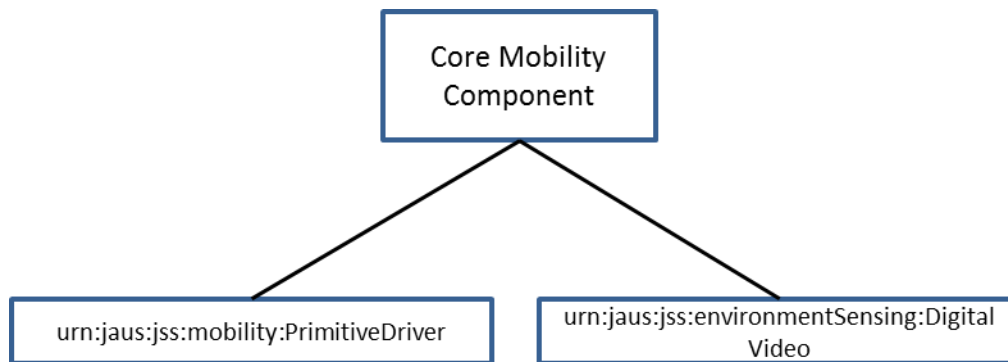


Figure 4.1-2: Example of Singleton Core Mobility Component with the RC and Teleop attribute specified.

2. The active mobility JAUS component shall be tied into the platform mode if available. A mobility component shall release control of low level mobility capabilities of the platform when the platform mode does not correspond to that mobility component.

The following rule set governs how and when control of a platform's Core Mobility JAUS Component is released. Rules 1-3 shall be used when the Platform Management Interoperability Attribute is specified with a value of "None" (no platform manager = no platform modes), and rules 4-5 shall be used when the Platform Management Interoperability Attribute has a value other than "None".

1. Any on-board mobility device shall use the platform's core Mobility JAUS Component to effect platform motion. Consequently, any on-board mobility device shall follow the Mobility Component's requirements for access control (mutual exclusion).
2. Any on-board mobility device shall release control of the platform's Core Mobility JAUS Component when it is no longer required to affect platform motion.
 - 2.1. A waypoint driver service shall release control of the platform's Core Mobility JAUS Component when a waypoint plan is canceled or completed.
 - 2.2. A leader/follower service shall release control of the platform's Core Mobility JAUS Component when the follower is commanded to stop following the leader.
 - 2.3. A vector driver service shall release control of the platform's Core Mobility JAUS Component when it is no longer being controlled by a client.

Unclassified

3. A client may request control of the platform's Core Mobility JAUS Component at a rate not to exceed 1 Hz.
4. Any on-board mobility device shall release control of the platform's core Mobility JAUS Component when the platform mode changes to a mode that does not correspond to the services provided by the mobility device.

Table 4.1-5: Operational Modes and Services that Correspond to Them

| Mode | Services |
|----------------------------------|--|
| Operational::RC | Primitive Driver, Velocity State Driver |
| Operational::Teleop | Primitive Driver, Velocity State Driver |
| Operational::Waypoint Navigation | Global Waypoint Driver, Local Waypoint Driver, Global Waypoint List Driver, Local Waypoint List Driver |
| Operational:: Leader/Follower | Leader Follower Driver |

- 4.1. A driver providing/ using the Primitive Driver and/or Velocity State Driver service(s) shall release control of the core Mobility JAUS Component upon the Platform Mode changing to something other than Operational::RC/Teleop.
- 4.2. A driver providing/ using any of the Waypoint Driver or Waypoint List Driver services shall release control of the core Mobility JAUS Component upon the Platform Mode changing to something other than Operational::Waypoint Nav.
- 4.3. A driver providing/ using the Leader Follower Driver service shall release control of the core Mobility JAUS Component upon the Platform Mode changing to something other than Operational::Leader/Follower.
5. Any on-board mobility device providing a service from more than one mode mapping (i.e. a guarded teleop + waypoint nav device that provides a Velocity State Driver and a Global Waypoint Driver) shall be allowed to maintain control on the platform's core mobility component in any of the modes it maps to. (i.e. it does not have to release control once the mode transitions if the mode transitions to a mode it maps to - this is an exception to rule 4.1-4.3)

4.1.2.2.3 **Access Control Timeout**

The access control timeout feature of the urn:jaus:jss:core:AccessControl service as defined in *AS5710 JAUS Core Service Set* is used for maintaining liveness of control. This liveness differs from the connection liveness offered by the Liveness service and instead provides a way for the server to detect the presence of the client. As stated in the description of the access control service, a timeout is set that corresponds to the rate at which a controlling client component must periodically request control of a server component, releasing control if the timeout is exceeded. **If not explicitly defined by a user of the Access Control Interoperability Attribute, the value of the access control timeout shall be 60 seconds.**

4.1.3 **ID Assignment Interoperability Attribute [Mandatory, Mutually Exclusive]**

The ID Assignment Interoperability Attribute specifies values that define methods for assigning unique JAUS IDs to JAUS subsystems, nodes, and components.

4.1.3.1 **Static Value**

If the Static attribute Value is specified, the assignment of unique JAUS identifiers shall be done at set-up / configuration time. The exact way in which this is done is not specified by this IOP

document, but typical methods include through a configuration file or other field-modifiable approach. If the Static attribute Value is selected, a method for ensuring the assignment and maintenance of unique JAUS identifiers must be used.

4.1.3.2 Centralized Value

If the Centralized attribute Value is specified, the assignment of unique JAUS identifiers shall be done using a run-time centralized approach for ID assignment. Specific details of this Value are deferred until a later revision of this document.

4.1.3.3 IP-Based Value

If the IP-Based attribute Value is specified, the assignment of unique JAUS identifiers shall be done based upon IP addresses. IP addresses shall be mapped to JAUS addresses following these rules:

- The Subsystem ID shall be based on the IP-address of the external-facing network interface, using the last 2 bytes (2 octets).
- The Node ID for any on-board device shall be based on the IP-address of the internal-facing network interface, using the last 1 byte (1 octet).
- The Component ID shall be set by the specific implementation

4.1.4 Transport Interoperability Attribute [Mandatory, Multiple]

The Transport Interoperability Attribute provides mutually exclusive options for which transport is used in the transport of messages. If multiple values are selected for this attribute, that implies that multiple transports are supported.

4.1.4.1 JUDP Value

If the JUDP Value is selected, the JAUS over UDP (JUDP) transport as defined in *AS5669A JAUS/SDP Transport Specification* shall be used for transport of messages. If selected, the type of broadcast used must be specified using the **[parameter]** BroadcastType (Default = Multicast). The valid values for BroadcastType are Multicast (using UDP Multicast to perform a JAUS broadcast) or Broadcast (using UDP Broadcast to perform a JAUS broadcast). If the Multicast value for the BroadcastType parameter is used, then another **[parameter]** MulticastAddress (default = as specified in *AS5669A JAUS/SDP Transport Specification*) must provide a valid Multicast address that will be used by all transport elements.

A **[parameter]** IP Address Assignment List Method (default = none) shall also be defined when using the JUDP Value. The IP Address Assignment List Method specifies how the IP Address Assignment List (see 3.1 Definitions for definition) is made available between Transport Layer Routing elements (see 3.1 Definitions for definition). One IP address may be associated with multiple JAUS IDs (i.e. two components on one node associated with one IP address). Possible methods for providing the IP Address Assignment List Method include but are not limited to a-priori methods (read out of a file, hard-coded), dynamic methods (broadcast/multicast of IP Address Assignment List using some message format), and central registry type methods (all Transport Layer Routing elements register IP Address Assignment List with a registry at a known location and retrieve that information from there). The IP Address Assignment List method parameter shall also specify the fallback in case a logical ID is not associated with a transport layer endpoint (for example, a broadcast could be used when the IP address associated with a specific JAUS ID is not known).

4.1.4.2 JTCP Value

If the JTCP Value is selected, then JAUS over TCP (JTCP) transport as defined in AS5669A *JAUS/SDP Transport Specification* shall be used for transport of messages.

A **[parameter]** IP Address Assignment List Method (default = none) shall also be defined when using the JTCP Value, as specified in 4.1.4.1 JUDP Value, with the following exception: a fallback in case the transport layer endpoint of a given logical JAUS ID is unknown does not need to be specified.

4.1.4.3 Custom Transport Value

If the Custom Transport Value is selected, a custom transport as defined in the *Custom Services, Messages, and Transports* IOP document shall be used. The specific transport being used defined in the *Custom Services, Messages, and Transports* IOP document may be specified.

4.1.5 Component Liveness Interoperability Attribute [Mandatory]

The Component Liveness Interoperability Attribute defines how the urn:jaus:jss:core:liveness JAUS service is used to maintain connection liveness between a JAUS component and a client. The Liveness service shall be the default way that a client maintains connectivity to a server component (a component that provides services for use). If specifically defined by another Interoperability Attribute, receiving regular, periodic messages from another service other than Liveness may be used to maintain connectivity to a server component.

4.1.5.1 Component and Service Requirements

All JAUS components that act as server components are required to provide the urn:jaus:jss:core:Liveness service.

Table 4.1-6: Component and Service Requirements for Component Liveness

| JAUS Component Providing Liveness | |
|-----------------------------------|------------------------------|
| Service | Reference |
| urn:jaus:jss:core:Liveness, v1.0 | AS5710 JAUS Core Service Set |

4.1.5.2 Notes and Interpretations

The Platform Manager JAUS component's Liveness service shall be used to maintain liveness from client subsystems (such as an OCU).

4.1.5.3 Periodicity

Every JAUS component providing component liveness through the Liveness service shall support periodic event for the ReportHeartbeatPulse message based on the rate specified in **[parameter]** HeartbeatRate (default = 1 Hz). A value of 0 provided for the HeartbeatRate parameter indicates that periodic events do not need to be supported (i.e. polling for ReportHeartbeatPulse by sending periodic QueryHeartbeatPulse messages from a client).

4.2 Platform Interoperability Attributes and Attribute Options

Platform Interoperability Attributes are platform-centric attributes that provide platform level capabilities such as discovery, engine status information, health information, etc. Platform

Unclassified

Interoperability Attributes and Attribute Options are part of the Platform attribute group. The Platform attributes include:

Table 4.2-1: Platform Management Attributes

| Attribute Name | Attribute Values | Description |
|--|------------------|--|
| Platform Management [Mandatory, Mutually Exclusive] | Basic | Defines basic platform services such as discovery, liveness, power plant management, odometry, mode, and health monitoring. |
| | Advanced | In addition to the Basic Platform Management services, adds in more advanced capabilities such as Built-In-Test(BIT) / Fault Isolation Test (FIT) and calibration. |
| | None | Specifies that no platform management capability is provided. |

4.2.1 Platform Management Interoperability Attribute [Mandatory, Mutually Exclusive]

4.2.1.1 Basic Platform Management Value

The Basic Platform Management Value incorporates the most basic level of capability for getting platform information and managing a platform subsystem. If the Basic Platform Management attribute Value is selected, a Basic Platform Manager JAUS component shall be provided under the Platform JAUS node. The JAUS address of the Basic Platform Manager JAUS component shall be [Subsystem ID].[Mobility Node ID].1.

4.2.1.1.1 *Component and Service Requirements*

The Basic Platform Manager value shall provide one Basic Platform Manager component under the Platform node. The Basic Platform Manager shall provide the following services:

Table 4.2-2: Component and Service Requirements for Basic Platform Manager

| Basic Platform Manager Component | |
|--|---|
| Service | Reference |
| urn:jaus:jss:core:Discovery, v1.0 | AS5710 JAUS Core Service Set |
| urn:jaus:jss:core:Liveness, v1.0 | AS5710 JAUS Core Service Set |
| urn:jaus:jss:ugv:PowerPlantManager, v0.1 | AS6091 JAUS UGV Service Set |
| urn:jaus:jss:ugv:Odometry, v0.1 | AS6091 JAUS UGV Service Set |
| urn:jaus:iop:platformmanager:PlatformMode, v1.0 | Custom Services, Messages, and Transports |
| urn:jaus:iop:platformmanager:HealthMonitor, v1.0 | Custom Services, Messages, and Transports |
| urn:jaus:iop:platformmanager:PresetPose, v1.0 | Custom Services, Messages, and Transports |

4.2.1.1.2 *Notes and Interpretations*

4.2.1.1.2.1 **Discovery**

The discovery service shall be provided as specified as in *AS5710 JAUS Core Service Set*, with the following additional messaging requirements:

Table 4.2-3: Message Interpretations for Discovery Service

| Message(s) | Concept | Interpretations |
|---|-----------------------|--|
| ID 2B00: QueryIdentification ID 4B00: ReportIdentification | Finding and Losing | The QueryIdentification message shall be sent by each component on a subsystem at a rate specified |

Unclassified

| | | |
|---------------------------|-----------------------------------|---|
| ID 0B00: RegisterServices | Subsystem Discovery Service | in the Periodicity section. If a corresponding ReportIdentification message is not received within 5 seconds, two more retries will be attempted. If ReportIdentification is still not received, the Discovery service shall be considered lost. When a Discovery service is found after being considered lost, the RegisterServices message shall be sent to the Discovery service containing information on all services the component provides, including the core services. |
|---------------------------|-----------------------------------|---|

4.2.1.1.2.2 Liveness

The liveness service provided by the Platform Manager JAUS component shall be used by an OCU or other client to maintain liveness to the Platform Manager.

4.2.1.1.2.3 Power Plant Manager

The following message interpretations apply for the Power Plant Manager service:

Table 4.2-4: Message Interpretations for Power Plant Manager Service

| Message(s) | Concept | Interpretations |
|------------------------------------|--------------------|--|
| ID 4508: ReportPowerPlantStatus | Reporting Types | Only the record or records that apply to the power plant capabilities of the vehicle shall be used when sending a ReportPowerPlantStatus message. For example, if a vehicle with a diesel engine and battery is reporting information, it shall provide the batteryStatus and dieselEngineStatus records, and not the gasolineEngineStatus record. |
| ID 4506: ReportPowerPlantState | Reporting Types | For reporting engine RPM, the record corresponding to the type of engine (either gasEngineState for a gasoline engine or dieselEngineState for a diesel engine) shall be used. |

4.2.1.1.2.4 Odometry

The following message interpretations apply for the Odometry service:

Table 4.2-5: Message Interpretations for Odometry Service

| Message(s) | Concept | Interpretations |
|------------------------|---------|---|
| ID 0515: QueryOdometry | Usage | A value of PLATFORM for the OdometryType shall be used to request the distance traveled by the platform since it began service. A value of TRIP_A shall be used to query the distance traveled on the current trip. The current trip starts whenever an external entity, such as an OCU, issues a ResetOdometry message with a value of TRIP_A. |
| 4516: ResetOdometry | Usage | This message shall be used with a value of TRIP_A to start a new trip. |

4.2.1.1.2.5 Health Monitor

The Health Monitor service is utilized in gathering and reporting the health of components and services on the UGV platform. This enumeration of states is defined as:

Unclassified

- Failure – The reported component or service has failed in a way that it is not usable. Failure implies a state that is not recoverable on the fly and corresponds to the Failure state of the Management service.
- Emergency – The reported component or service is in an emergency state. This corresponds to the Emergency state of the Management service.
- Degraded – The reported component or service has degraded performance – it is still usable and functional, but it may have reduced data rate, reduced accuracy, or some other issue that decreases its effectiveness.
- Comms Lost – Communications (liveness) to the reported component have been lost. The Comms lost enumeration is not valid for service health reports since the Liveness service is used to determine this state.

For IOP Version 0, only the QueryComponentHealth and ReportComponentHealth messages of the Health Monitor service are required. For IOP Version 0, only the Failure, Comms lost, and Emergency health states are required.

The following message interpretations apply for the HealthMonitor service:

Table 4.2-6: Message Interpretations for Health Monitor Service

| Message(s) | Concept | Interpretations |
|-----------------------------------|-------------------------------------|--|
| ID FF12: ReportComponentHealth | Emergency and Failure Health States | The HealthState field of the ComponentHealthRec shall be set to Failure or Emergency based on the Management service state of a component. If a component does not provide a Management service, these health states are not possible. |
| | Comms Lost State | If liveness to a component is lost (urn:jaus:jss:core:Liveness service), the Health Monitor service shall report health state as 3: Comms Lost. |

4.2.1.1.2.6 Platform Mode

There are no notes or interpretations for Platform Mode.

4.2.1.1.2.7 Preset Pose

The Preset Pose service is used to set and query/report preset poses for a platform, where a pose refers to a particular orientation and position of various arms, flippers, and manipulators. The following message interpretations apply for the Preset Pose service:

Table 4.2-7: Message Interpretations for Preset Pose Service

| Message(s) | Concept | Interpretations |
|------------------------|------------|--|
| ID FFFD: SetPresetPose | Stow Pose | The Stow pose is defined as a pose where all actuated devices are in a position that best compacts the platform for stowing within its container or other enclosed area. |
| | Drive Pose | The Drive pose is defined as a pose best suited to normal driving. |

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| | | |
|--|-------------|---|
| | Deploy Pose | The Deploy pose is defined as a pose best suited to deployment of a platform. |
|--|-------------|---|

4.2.1.1.3 *Periodicity*

4.2.1.1.3.1 **Liveness**

- ID 2202: QueryHeartbeatPulse/ ID 4202: ReportHeartbeatPulse - The Platform Manager JAUS component's Liveness service can be used to maintain connectivity to a platform. A rate of at least once per 5 seconds is recommended.

4.2.1.1.3.2 **Health Monitor**

- ID 2202: QueryHeartbeatPulse/ ID 4202: ReportHeartbeatPulse - The Health Monitor shall check for connectivity to each JAUS component on the subsystem at a rate of at least once per 60 seconds for every component on the subsystem, and at least once per second for the Core Mobility JAUS component.

4.2.1.1.3.3 **Discovery**

- ID 2B00: QueryIdentification – A QueryIdentification message shall be broadcast by every JAUS component on the subsystem at a rate of at least once per 5 minutes for the purpose of finding and registering services with the Discovery service.

4.2.1.2 **Advanced Platform Management Value**

The Advanced Platform Management Value of the Platform Management Interoperability Attribute is reserved for providing future capabilities such as calibration, software updates, etc. .

4.2.1.3 **None Attribute Value**

The None attribute Value for the Platform Management Interoperability Attribute implies that there is no Platform Manager JAUS node or component(s), that discovery is not provided, and that locations of JAUS nodes, components, and services must be known apriori. An example of a subsystem using no Platform Manager is a legacy system converted to use IOP standards, but with static and known JAUS addresses that messages are always sent to.

4.3 ***Mobility Interoperability Attributes and Attribute Options***

Mobility Interoperability Attributes define capabilities related to platform mobility, such as driving. Multiple Mobility Interoperability Attributes may be selected that add the same service to the Core Mobility JAUS component – in this case, only one service is considered added. Mobility Interoperability Attributes and Attribute Options are part of the Mobility attribute group. The following Mobility Interoperability Attributes and Attribute Options are defined:

Table 4.3-1: Mobility Interoperability Attributes

| Attribute Name | Attribute Values | Description |
|--|-------------------------|---|
| Core Mobility Component [Mandatory] | Default | Defines a Core Mobility component that must be provided on any subsystem that provides mobility services. |
| Drive Timeout [Mandatory] | Default | Defines a mandatory drive timeout for any mobility service. |

Unclassified

| | | |
|--|---------|--|
| Safety Requirements [Mandatory] | Default | Defines requirement for emergency stop capability for Core Mobility Component. |
| Remote Control (RC) [Selectable] | Default | Defines the capability to remotely control a vehicle, line of sight. |
| Teleoperation (Teleop) [Selectable] | Default | Defines the capability to teleoperate a vehicle, non-line of sight, using a driving video source. |
| Basic Navigation (BN) [Selectable, Multiple] | Local | Defines the capability for navigation using waypoint path following with locally referenced waypoints. |
| | Global | Defines the capability for navigation using waypoint path following with globally referenced waypoints. |
| Leader Follower (LF) [Selectable] | Default | Defines capability to perform leader follower navigation, such as in a convoy. |
| Mobility Limits [Selectable] | Default | Defines the capability to get information on the inherent mobility limits (speed and acceleration) of a vehicle. |

Table 4.3-2: Mobility Attribute Options

| Attribute Option Name | Description |
|-----------------------|--|
| Gear | Adds the capability to explicitly control gears. |
| Velocity State Driver | Adds the capability to perform closed loop velocity control. |

4.3.1 Core Mobility Component Interoperability Attribute [Mandatory]

Any subsystem that provides mobility services, such as a primitive driver or velocity state driver, shall provide a Core Mobility JAUS component under the Mobility JAUS node. All subsystem mobility services that control core mobility, as defined in the selectable Mobility Interoperability Attributes, shall be placed under the Core Mobility JAUS component to allow for mutually exclusive access control to low level drive services as specified in 4.1.2.2.2 Mutually Exclusive Access Control.

4.3.2 Drive Timeout Interoperability Attribute [Mandatory]

There shall be a drive timeout set of values specified for the use of the platform Core Mobility JAUS component. These values shall specify the maximum amount of time between mobility messages to the platform's Core Mobility JAUS component before the platform specific mobility driver is told to stop for safety reasons. These values are based on the speed of the vehicle, dynamics of the vehicle, and other internal and external factors. Once a drive timeout has occurred, the vehicle shall stay in a stopped state until mobility messages are received again for a specified amount of time at a specified minimum rate. The time and rate are also determined by the particulars of the vehicle and the environment it is expected to operate in. To meet the drive timeout attribute requirements, values must be specified for the following parameters (see Figure 4.3-1 for explanation of states):

- **[Parameter]** Drive Timeout time (default = 1 second) – The time after receiving the last drive message (i.e. a SetWrenchEffort or SetVelocityState message) at which a Drive Timeout is considered to occur.
- **[Parameter]** Drive Frequency (default = None) - The frequency and acceptable variation at which drive messages must be received. If this frequency is not maintained, a Drive Timeout is considered to occur.

- **[Parameter]** Drive Recovery time (default = 1 second) – The amount of time over which drive messages must be received at the specified Drive Frequency before transitioning out of a Drive Timeout state to a Normal Drive state.

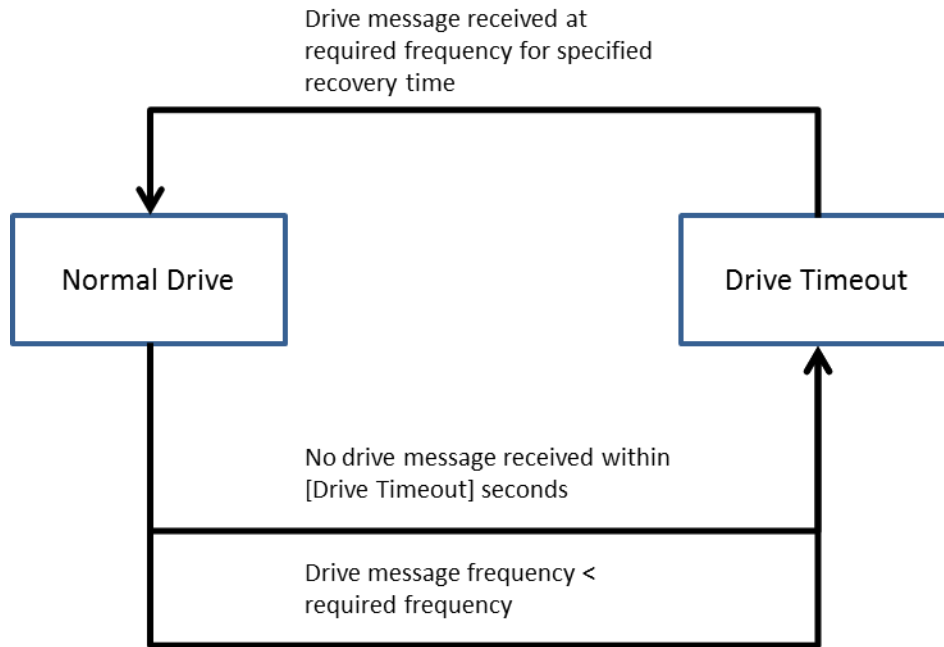


Figure 4.3-1: States for Drive Timeout

4.3.3 Safety Requirements Interoperability Attribute [Mandatory]

The Safety Requirements Interoperability Attribute defines capabilities required to maintain safe operation of a platform. Currently, emergency stopping a drive service on the Core Mobility JAUS component is the only required safety requirement.

The emergency stop safety requirement provides the capability to stop a platform in a safe manner (note that this does not necessarily mean just setting 0 velocity). Safe implies that the platform will no longer be moving and will not be in a position to move on its own (i.e. slide down a slope because a parking brake is not engaged).

4.3.3.1 Component and Service Requirements

The Management service on the Core Mobility JAUS component is used to set an emergency (safe) stop. A Management service will always be present on the Core Mobility JAUS component since all driver services inherit from it.

4.3.3.2 Notes and Interpretations

The following message interpretations are used for the Management service:

Table 4.3-3: Notes and Interpretations for Safety Requirements Interoperability Attribute

| Message(s) | Concept | Interpretations |
|-----------------------|---------|--|
| ID 0006: SetEmergency | Usage | The value SAFETY = 2 is added to the enumeration for emergency code. SAFETY implies a safe stop and does not necessarily mean just 0 motion. |

4.3.3.3 Periodicity

There are no special periodicity requirements for the Safety Requirements attribute.

4.3.4 Remote Control Interoperability Attribute [Selectable]

If selected, the Remote Control Interoperability Attribute provides the capability to control a platform via line of sight remote control.

4.3.4.1 Component and Service Requirements

All services provided by the Remote Control Interoperability Attribute shall be added to the Core Mobility JAUS component.

Table 4.3-4: Components and Services for Remote Control Attribute

| Core Mobility Component (Added to) | |
|---|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:PrimitiveDriver, v1.0 | AS6009 JAUS Mobility Service Set |

4.3.4.2 Notes and Interpretations

The following message interpretations apply for the Primitive Driver service.

Table 4.3-5: Message Interpretations for Remote Control Interoperability Attribute

| Message(s) | Concept | Interpretations |
|---|-----------------------|---|
| ID 0405: SetWrenchEffort ID 2405: QueryWrenchEffort ID 4405: ReportWrenchEffort | Platform Acceleration | <ul style="list-style-type: none"> - Propulsive Linear Effort X: positive values indicate the percent of maximum forward effort. Negative values indicate the percent of maximum reverse effort. - Vehicle with gear select: By default, there is no message set for selecting gears – a positive value of Propulsive Linear Effort X will indicate throttle level to be used while in drive, and a negative value will automatically cause the platform to shift into an appropriate gear for travelling in reverse. If the gear attribute option is selected, gears shall be selected as defined in 4.3.10 Gear Attribute Option Gear Attribute Option. |
| | Platform Deceleration | <ul style="list-style-type: none"> - Some platforms will decelerate with decrease in Propulsive Linear Effort X due to resistive force inherent in the drive motor when power is decreased or not applied. - Resistive Linear Effort X: The value will be translated to braking force against platform movement in forward or reverse direction on platforms that support braking. |
| | Platform Steering | <ul style="list-style-type: none"> - Propulsive Rotational Effort Z: Positive values indicate steering to the right, negative values indicate steering to the left, as a percentage of maximum rotational effort. - Skid steer vehicles: If platform velocity is non zero (or above some minimum threshold value), value of 100 will indicate maximum propulsive effort on left traction component and minimum on the right. A |

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| | | |
|--|------------------------|--|
| | | value of -100 will indicate maximum propulsive effort on right traction component and minimum on the left. If platform velocity is zero, positive values indicate pivot clockwise (as seen from above the platform), and negative values indicate pivot counter clockwise. - Multiple axis steering vehicles are not covered in this version. |
| | Speed/Effort Reporting | The reported wrench effort may not correspond exactly with the actual speed of the vehicle, and should not be used for performing any closed loop control. |

4.3.4.3 Periodicity

ID 0405: Set Wrench Effort - The set wrench effort command is a periodic command that must be sent at a rate sufficient for the safe operation of the vehicle at a given speed. This rate is determined by the speed rating as well as the intended use of the platform. Safe operations must be considered to set the minimum rate required for a given speed. The actions taken if this message is not received at a given rate or within a given amount of time are specified in 4.3.2 Drive Timeout Interoperability Attribute [Mandatory].

4.3.5 Teleoperation (Teleop) Interoperability Attribute [Selectable]

If selected, the Teleoperation (Teleop) Interoperability Attribute provides the capability to teleoperate a platform (non-line of sight, with video feed).

4.3.5.1 Component and Service Requirements

The Teleop Interoperability Attribute adds a Primitive Driver service and Digital Video and/or Analog Video service to the Core Mobility JAUS component. The Digital/Analog Video service represents a drive video source which would typically be from a single camera, but could also be a fused video source from multiple cameras. Digital or analog video is specified in [parameter] Video Type (Default = DigitalVideo).

Table 4.3-6: Components and Services for Teleoperation Interoperability Attribute

| Core Mobility Component (Added to) | |
|---|---|
| Service | Reference |
| urn:jaus:jss:mobility:PrimitiveDriver, v1.0 | AS6009 JAUS Mobility Service Set |
| urn:jaus:jss:environmentSensing:DigitalVideo, v1.0 and/or urn:jaus:jss:environmentSensing:AnalogVideo, v1.0 | AS6060 JAUS Environment Sensing Service Set |

In addition, the Teleop Interoperability Attribute shall add the following service to the JAUS component defined by the Platform Management Interoperability Attribute (if there is none, a new JAUS component under the Platform JAUS node shall be created). Only a single instance of this service shall be provided – if multiple Interoperability Attributes or Attribute Options are specified that require it, it shall be treated as the same service for all of them.

Table 4.3-7: Components and Service added to Platform Manager for the Teleoperation Interoperability Attribute

| Component Provided by Platform Manager Attribute (new component if value = none) | |
|---|---|
| Service | Reference |
| urn:jaus:iop:DigitalStreamDiscovery, v0.1 | Custom Services, Messages, and Transports |

4.3.5.2 Notes and Interpretations

See Section 4.3.4.2 Notes and Interpretations for the Remote Control Interoperability Attribute for interpretations for the Primitive Driver service.

4.3.5.3 Periodicity

See Section 4.3.4.3 Periodicity for the Remote Control Interoperability Attribute for periodicity requirements for Primitive Driver service messages.

4.3.6 Basic Navigation (BN) Interoperability Attribute [Selectable, Multiple]

If selected, the Basic Navigation (BN) Interoperability Attribute provides the ability to move/drive the platform via a defined set of points specified by an external source.

4.3.6.1.1 *Global Attribute Value*

The Global attribute Value specifies the use of global waypoints. Global waypoints are globally referenced using WGS84 and are typically going to be obtained from a Global Positioning System (GPS) device.

4.3.6.1.1.1 Component and Service Requirements

The Global attribute Value of the Basic Navigation Interoperability Attribute shall add its service to the Core Mobility JAUS component if it is specified as part of a platform's core mobility.

Table 4.3-8: Components and Services for Global Value of the Basic Navigation Interoperability Attribute (Core mobility)

| Core Mobility Component (added to) | |
|--|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:GlobalWaypointDriver, v1.0 | AS6009 JAUS Mobility Service Set |
| urn:jaus:jss:mobility:GlobalWaypointListDriver, v1.0 | AS6009 JAUS Mobility Service Set |

If not part of the platform's core mobility, the Global attribute Value of the Basic Navigation Interoperability Attribute shall add its services to a JAUS component that is provided by this attribute Value.

Table 4.3-9: Components and Services for Global Value of Basic Navigation Interoperability Attribute

| Basic Navigation Component | |
|--|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:GlobalWaypointDriver, v1.0 | AS6009 JAUS Mobility Service Set |
| urn:jaus:jss:mobility:GlobalWaypointListDriver, v1.0 | AS6009 JAUS Mobility Service Set |

4.3.6.1.1.2 Notes and Interpretations

There are not notes or message interpretations for the Global attribute Value of the Basic Navigation Interoperability Attribute.

4.3.6.1.1.3 Periodicity

There are no special periodicity requirements for the Global attribute Value of the Basic Navigation Interoperability Attribute.

4.3.6.1.2 Local Attribute Value

The Local attribute Value specifies the use of local waypoints. Local waypoints are locally referenced, often to the platform, using a variety of techniques. For additional control over the local frame of reference, the Local Position and Attitude Attribute Option can be added to this component.

4.3.6.1.2.1 Component and Service Requirements

The Local attribute Value of the Basic Navigation Interoperability Attribute shall add its service to the Core Mobility JAUS component if it is specified as part of a platform's core mobility.

Table 4.3-10: Components and Services for Local Value of Basic Navigation Interoperability Attribute (Core mobility)

| Core Mobility Component (added to) | |
|---|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:LocalWaypointDriver, v1.0 | AS6009 JAUS Mobility Service Set |
| urn:jaus:jss:mobility:LocalWaypointListDriver, v1.0 | AS6009 JAUS Mobility Service Set |

If not part of the platform's core mobility, the Local attribute Value of the Basic Navigation Interoperability Attribute shall add its services to a JAUS component that is provided by this attribute Value.

Table 4.3-11: Components and Services for the Local Value of the Basic Navigation Interoperability Attribute

| Basic Navigation Component | |
|---|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:LocalWaypointDriver, v1.0 | AS6009 JAUS Mobility Service Set |
| urn:jaus:jss:mobility:LocalWaypointListDriver, v1.0 | AS6009 JAUS Mobility Service Set |

4.3.6.1.2.2 Notes and Interpretations

There are not notes or message interpretations for the Local attribute Value of the Basic Navigation Interoperability Attribute.

4.3.6.1.2.3 Periodicity

There are no special periodicity requirements for the Local attribute Value of the Basic Navigation Interoperability Attribute.

4.3.7 Leader Follower (LF) Interoperability Attribute [Selectable]

If selected, the Leader/Follower (LF) Interoperability Attribute provides the ability to specify the robotic platform leader/follower mode within a leader/follower configuration. For this basic capability, the robotic platform will be designated as a "Leader", "Follower" or both. The intent of

the leader capability requirement is to provide a simple position designation to a set of external followers. The intent of the follower capability is to monitor a simple position report from a designated follower and follow the position in accordance with a defined set of values.

4.3.7.1.1 **Component and Service Requirements**

If part of the platform's core mobility, the Leader Follower Interoperability Attribute shall add the following services to the Core Mobility JAUS component:

Table 4.3-12: Components and Services for Leader Follower Interoperability Attribute (Core Mobility)

| Core Mobility Component (added to) | |
|---|---|
| Service | Reference |
| urn:jpo:autonomy:LeaderManagementService , v0.1 | Custom Services, Messages, and Transports |
| urn:jpo:autonomy:LeaderFollowerDriver, v0.1 | Custom Services, Messages, and Transports |

If not part of the platform's core mobility, the Leader Follower Interoperability Attribute shall provide a JAUS component that provides the following services:

Table 4.3-13: Components and Services for Leader Follower Interoperability Attribute

| Leader Follower Component | |
|---|---|
| Service | Reference |
| urn:jpo:autonomy:LeaderManagementService , v0.1 | Custom Services, Messages, and Transports |
| urn:jpo:autonomy:LeaderFollowerDriver, v0.1 | Custom Services, Messages, and Transports |

4.3.7.1.2 **Notes and Interpretations**

There are no notes or interpretations for the Leader Follower Interoperability Attribute.

4.3.7.1.3 **Periodicity**

There are no special periodicity requirements for the Leader Follower Interoperability Attribute.

4.3.8 **Mobility Limits Interoperability Attribute [Selectable]**

If selected, the Mobility Limits Interoperability Attribute provides the capability to query the mobility limits inherent to (not associated with a particular type of driver) the platform, including limits for maximum speed and acceleration.

4.3.8.1 **Component and Service Requirements**

The Mobility Limits Interoperability Attribute shall provide a Mobility Limits JAUS component under the Mobility JAUS Node.

Table 4.3-14: Components and Services for Mobility Limits Interoperability Attribute

| Mobility Limits Component | |
|---|---------------------------------------|
| Service | Reference |
| urn:jaus:jss:ugv:PlatformSpecifications, v0.1 | AS6091 JAUS UGV Service Set Draft 0.5 |

4.3.8.2 **Notes and Interpretations**

The following message interpretations apply for the Platform Specifications service.

Table 4.3-15: Notes and Interpretations for Mobility Limits Interoperability Attribute

| Message(s) | Concept | Interpretations |
|---|---------|--|
| ID 2502: QueryPlatformSpecifications ID 4502: ReportPlatformSpecifications | Usage | The PlatformInertialSpecificationsRec shall be used to return the speed and acceleration/deceleration limits of the platform. Forward implies positive X direction and negative implies negative X direction |

4.3.8.3 Periodicity

There are no special periodicity requirements for the Mobility Limits Interoperability Attribute.

4.3.9 Velocity State Driver Attribute Option

If used, the Velocity State Driver Attribute option adds the capability to drive a platform using closed loop velocity based control. This Attribute Option implies that the platform has the ability to sense its velocity.

4.3.9.1 Valid Interoperability Attribute Values

- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default

4.3.9.2 Component and Service Requirements

The Velocity State Driver Attribute Option shall add the following service to the Core Mobility JAUS component that the Remote Control and Teleoperation Interoperability Attributes specify:

Table 4.3-16: Components and Service for Velocity State Driver Attribute Option (Core Mobility)

| Core Mobility Component (added to) | |
|---|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility;VelocityStateDriver, v1.0 | AS6009 JAUS Mobility Service Set |

4.3.9.3 Notes and Interpretations

The following message interpretations for the Velocity State Driver service apply:

Table 4.3-17: Notes and Interpretations for Velocity State Driver Attribute Option

| Message(s) | Concept | Interpretations |
|--|--|---|
| ID 0415: SetVelocityCommand ID 0416: SetAccelerationLimit ID 2415: QueryVelocityCommand ID 2416: QueryAccelerationLimit ID 4415: ReportVelocityCommand ID 4416: ReportAccelerationLimit | Maximum Velocity | Optionally, the first SetVelocityCommand message issued to the platform shall set the maximum velocities that the platform is allowed to perform by specifying a command type of 1 (Set maximum allowed values). If maximum values are not set or are set above the inherent platform mobility limits, the inherent platform mobility limits shall be used. A QueryVelocityCommand message shall be used to confirm the limits are set. |
| | Platform Acceleration (increase in velocity) | <ul style="list-style-type: none"> - To achieve a particular velocity, the platform shall not exceed the acceleration limits set using the SetAccelerationLimit message. - Positive velocity is movement in the positive X |

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| | |
|--|--|
| | (forward) direction. |
| Platform Deceleration (decrease in velocity) | <ul style="list-style-type: none"> - To achieve a particular velocity, the platform shall not exceed the acceleration limits set using the SetAccelerationLimit message. - Negative velocity is movement in the negative X (reverse) direction |
| Vehicle with Gear Select | <ul style="list-style-type: none"> - A positive velocity in the X (forward) direction shall utilize a forward (drive) gear. - A negative velocity in the X (backward) direction shall utilize a reverse gear. |
| Platform Steering | <ul style="list-style-type: none"> - Yaw Rate: Positive values indicate steering to the right, negative values indicate steering to the left. - Skid Steer Vehicles: If platform velocity is non- zero (or above some minimum threshold value), a positive value shall pivot the vehicle around the right traction component, and a negative value shall pivot the vehicle around the left traction component, at the rate specified. If platform velocity is zero, positive values indicate pivot clockwise (as seen from above the platform), and negative values indicate pivot counter clockwise. - Multi-axle steering vehicles are not supported. |
| Acceleration Limit | A SetAcceleration limit message may be sent to the Velocity State Driver service to limit the acceleration used to accomplish the velocity desired. If acceleration limits are not set or are set above the inherent platform mobility limits, the platform mobility limits shall be used. A QueryAccelerationLimit message shall be used to confirm the limits are set. |

4.3.9.4 Periodicity

ID 0415: Set Velocity Command - This command is a periodic command that must be sent at a rate sufficient for the safe operation of the vehicle at a given speed. This rate is determined by the speed as well as the intended use of the platform. Safe operations must be considered to set the minimum rate required for a given speed. The actions taken if this message is not received at a given rate or within a given amount of time are specified in 4.3.2 Drive Timeout Interoperability Attribute [Mandatory].

4.3.10 Gear Attribute Option

Gear is an Attribute Option that is valid for the default value of the Remote Control and Teleoperation attributes. If the Gear Attribute Option is not used, then no additional services or messages for controlling the gear of a vehicle are specified, and gear select is handled as

defined in Remote Control Interoperability Attribute [Selectable] and 4.3.9 Velocity State Driver Attribute Option.

4.3.10.1 Valid Interoperability Attribute Values

- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default

4.3.10.2 Component and Service Requirements

The Gear Attribute Option shall add the following services to the Core Mobility JAUS component that Teleoperation and RC services are added to:

Table 4.3-18: Components and Services for Gear Attribute Option

| Core Mobility Component (added to) | |
|---|-----------------------------|
| Service | Reference |
| urn:jaus:jss:ugv:DriveTrainDriver, v0.1 | AS6091 JAUS UGV Service Set |

4.3.10.3 Notes and Interpretations

In order to confirm successful transition into a different gear, a client requesting a change in gear should set up an event to get notified of any changes in transmission state. Currently, if transition to a new gear does not occur, there is no way to report back the reason why – the client should wait for an update on the current gear and try to set the gear again if it does not change.

4.3.10.4 Periodicity

There are no special periodicity requirements for the Gear Attribute Option.

4.4 *Sensor and Emitter Interoperability Attributes and Attribute Options*

Sensor and emitter Interoperability Attributes provide capabilities to sense aspects inherent to a platform or the environment, and to emit energy or materials, respectively. Sensor and emitter Interoperability Attributes usually correspond to a single functional unit (i.e. a Digital Video Interoperability Attribute may correspond to a single camera) but also may correspond to a logical capability (i.e. a Digital Video Interoperability Attribute applying to a digital video stream fused together from multiple cameras). Sensor or emitter Interoperability Attributes may be selected for any JAUS node on a subsystem. If a sensor or emitter is an integrated component of a platform, such as a microphone or speaker incorporated as a part of a vehicle, the sensor or emitter attribute shall provide a JAUS component under the Platform JAUS node. If a sensor or emitter is a part of the platform's mobility capabilities, such as a velocity state sensor inherent to a vehicle's mobility driver, the sensor attribute shall provide a component under the Mobility JAUS node. Finally, if a sensor or emitter is part of a complex payload added to a vehicle (i.e. a Range Sensor Interoperability Attribute corresponding to a range sensor on an autonomy package), the attribute shall provide a JAUS component as part of that complex payload's JAUS node. Sensor and emitter Interoperability Attributes and Attribute Options are part of the Sensor and Emitter attribute group. The following sensor and emitter Interoperability Attributes are defined:

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Table 4.4-1: Sensor and Emitter Interoperability Attributes

| Attribute Name | Attribute Values | Description |
|---|-------------------------|--|
| Digital Video [Selectable, Multiple] | Default | Provides the capability to control and configure digital video, as well as find a digital video stream. Typically associated with a single camera, but may be associated with a fused video source or simulated video as well. |
| Still Image [Selectable, Multiple] | Default | Provides the capability to control and configure a still image source. |
| Range Finder [Selectable, Multiple] | Default | Provides the capability to configure and get information from a range finder sensor, such as a LADAR or RADAR. |
| Analog Video [Selectable, Multiple] | Default | Provides the capability to control and configure an analog video source. |
| Pan Tilt Video Sensor [Composed, Selectable, Multiple] | Default | An attribute composed of a pan tilt manipulator and either analog or digital video sensor that defines a tightly coupled pan tilt video capability, such as that provided by a pan-tilt-zoom camera. |
| Microphone [Selectable, Multiple] | Default | Provides the capability to get information from a sound input device (microphone). |
| Lights [Selectable] | Default | Provides the capability to find and configure platform lights, like driving lights and brake lights. |
| Speaker Attribute [Selectable, Multiple] | Default | Provides the capability to interact with a sound output device (a speaker). |

4.4.1 Digital Video Interoperability Attribute [Selectable, Multiple]

The Digital Video Interoperability Attribute provides a method for interacting with a digital video source, such as a digital camera or digital video from another digital source.

4.4.1.1 Component and Service Requirements

The Digital Video Interoperability Attribute shall provide a JAUS component under whichever JAUS node it is specified to apply to, providing the following services:

Table 4.4-2: Components and Services for Digital Video Interoperability Attribute

| Digital Video Component | |
|--|---|
| Service | Reference |
| urn:jaus:jss:environmentSensing;DigitalVideo, v1.0 | AS6060 JAUS Environment Sensing Service Set |

In addition, the Digital Video Interoperability Attribute shall add the following service to the JAUS component defined by the Platform Management Interoperability Attribute (if there is none, a new JAUS component under the Platform JAUS node shall be created). Only a single instance

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of this service shall be provided – if multiple Interoperability Attributes or Attribute Options are specified that require it, it shall be treated as the same service for all of them.

Table 4.4-3: Components and Services added to Platform Management Interoperability Attribute

| Component Provided by Platform Management Interoperability Attribute (new component if value = none) | |
|---|---|
| Service | Reference |
| urn:jaus:iop:DigitalStreamDiscovery, v0.1 | Custom Services, Messages, and Transports |

4.4.1.2 Notes and Interpretations

Figure 4.4-1 shows a sequence for using a Digital Video Service and Digital Video Endpoint Service to query and set digital video capabilities, control the digital video stream, and discover video protocol specific information.

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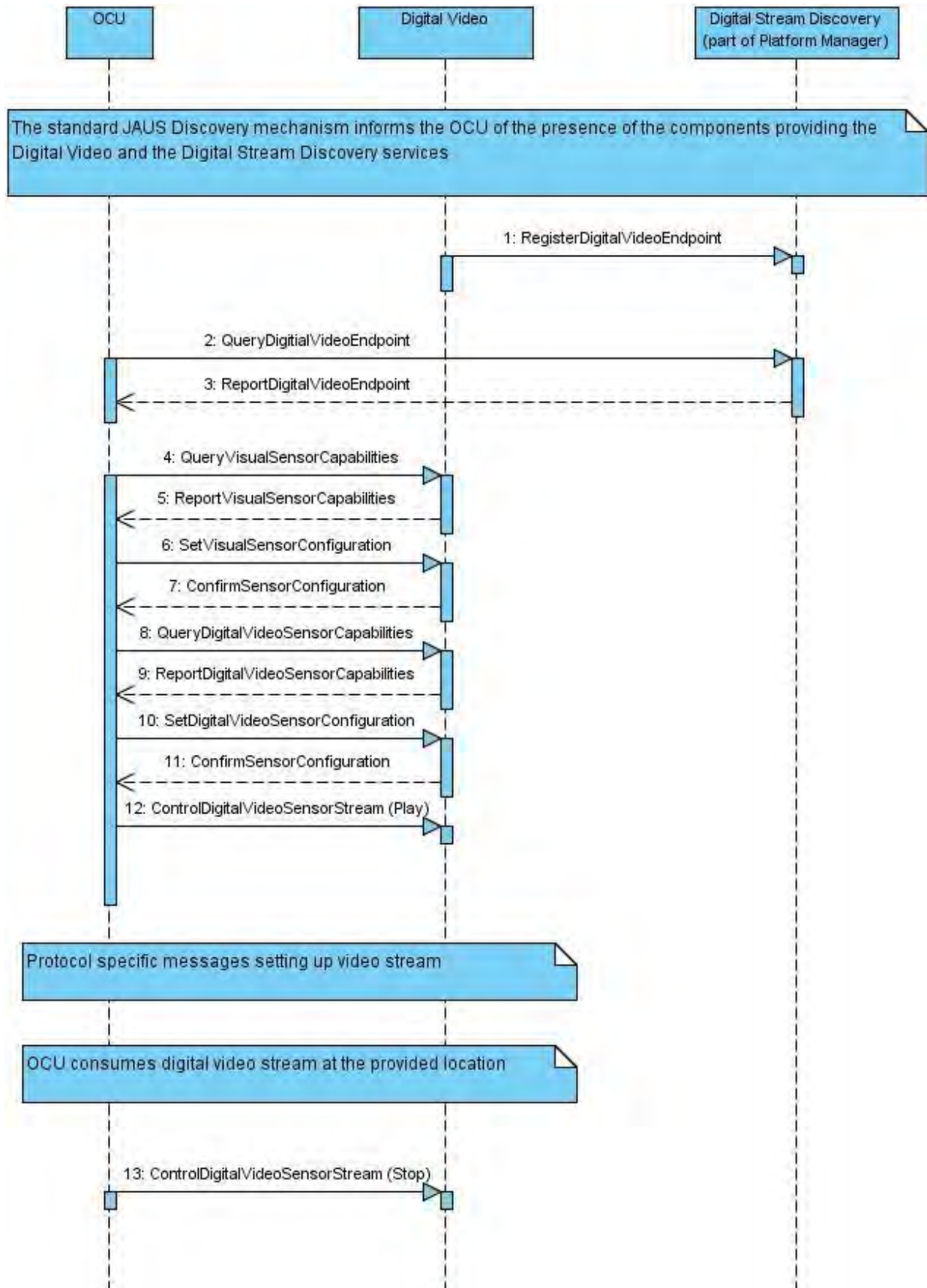


Figure 4.4-1: Sequence Diagram for Digital Video Service

The following message interpretations apply for the Digital Video Sensor service:

Table 4.4-4: Message Interpretations for Digital Video Interoperability Attribute

| Message(s) | Concept | Interpretations |
|---|-----------------------|---|
| ID 2806: QueryVisualSensorCapabilities ID 2807: QueryVisualSensorConfiguration ID 2805: QuerySensorGeometricProperties ID 0803: SetVisualSensorConfiguration ID 4806: ReportVisualSensorCapabilities ID 4807: ReportVisualSensorConfiguration ID 4805: ReportSensorGeometricProperties ID 0801: ConfirmSensorConfiguration | Use of SensorID Field | The values 1000 – 1032 are reserved SensorID values for drive cameras. Any Digital Video Sensor with a SensorID of between 1000 and 1032, inclusive, indicates that it is a digital video feed suitable for driving a platform. |

4.4.1.3 Periodicity

There are no special periodicity requirements for the Digital Video Interoperability Attribute.

4.4.2 Still Image Interoperability Attribute [Selectable, Multiple]

The Still Image Interoperability Attribute defines the capability to configure and retrieve information from a still image source.

4.4.2.1 Component and Service Requirements

The Still Image Interoperability Attribute shall provide a JAUS component under whichever JAUS node it is specified to apply to, providing the following services:

Table 4.4-5: Components and Services for Still Image Interoperability Attribute

| Still Image Component | |
|--|---|
| Service | Reference |
| urn:jaus:jss:environmentSensing;StillImage, v1.0 | AS6060 JAUS Environment Sensing Service Set |

4.4.2.2 Notes and Interpretations

There are no notes or interpretations for the Still Image Interoperability Attribute.

4.4.2.3 Periodicity

There are no special periodicity requirements for the Still Image Interoperability Attribute.

4.4.3 Range Finder Interoperability Attribute [Selectable, Multiple]

The Range Finder Interoperability Attribute provides the capability for getting information back from a range sensor. This may be either a simple range finder (one range, like a ranging laser) or a more complex range finder (like a LIDAR unit with many returns per second over a large azimuth).

4.4.3.1 Component and Service Requirements

The Range Finder Interoperability Attribute shall provide one JAUS component that provides the following services:

Table 4.4-6: Components and Services for Range Finder Interoperability Attribute

| Range Finder Component | |
|---|---|
| Service | Reference |
| urn:jaus:jss:environmentSensing;RangeSensor, v1.0 | AS6060 JAUS Environment Sensing Service Set |

4.4.3.2 Notes and Interpretations

The following message interpretations apply for the Range Sensor service:

Table 4.4-7: Notes and Interpretations for Range Finder Interoperability Attribute

| Message(s) | Concept | Interpretations |
|---|---|--|
| ID 4801: ReportRangeSensorCapabilities | Use of the CoordinateTransformationSupported field. | The value for support of coordinate transformations in a range sensor shall be 0 unless the CoordinateTransformationSupported field is provided with a value of 1. |
| ID 4803: ReportRangeSensorData | Use of RangeSensorDataPointRec | For a single point range sensor (i.e. a single distance ranging laser), the PointID field shall not be included. Bearing and inclination shall be set to 0 and 0 respectively unless the range sensor does not get distance straight ahead with regard to its reference frame. |

4.4.3.3 Periodicity

There are no special periodicity requirements for the Range Finder Interoperability Attribute.

4.4.4 Analog Video Interoperability Attribute [Selectable, Multiple]

The Analog Video Interoperability Attribute provides a method for interacting with an analog video source, such as an analog camera.

4.4.4.1 Component and Service Requirements

The Analog Video Interoperability Attribute shall provide a JAUS component under whichever JAUS node it is specified to apply to, providing the following services:

Table 4.4-8: Components and Services for Analog Video Interoperability Attribute

| Analog Video Component | |
|---|---|
| Service | Reference |
| urn:jaus:jss:environmentSensing;AnalogVideo, v1.0 | AS6060 JAUS Environment Sensing Service Set |

4.4.4.2 Notes and Interpretations

The following message interpretations apply for the Analog Video Sensor service:

Table 4.4-9: Message Interpretations for Analog Video Interoperability Attribute

| Message(s) | Concept | Interpretations |
|---|-----------------------|--|
| ID 2806: QueryVisualSensorCapabilities ID 2807: QueryVisualSensorConfiguration ID 2805: QuerySensorGeometricProperties ID 0803: SetVisualSensorConfiguration ID 4806: ReportVisualSensorCapabilities ID 4807: ReportVisualSensorConfiguration ID 4805: ReportSensorGeometricProperties ID 0801: ConfirmSensorConfiguration | Use of SensorID Field | The values 1000 – 1032 are reserved SensorID values for drive cameras. Any Analog Video Sensor with a SensorID of between 1000 and 1032, inclusive, indicates that it is an analog video feed suitable for driving a platform. |

4.4.4.3 Periodicity

There are no special periodicity requirements for the Analog Video Interoperability Attribute.

4.4.5 Pan Tilt Video Sensor Interoperability Attribute [Composed, Selectable, Multiple]

The Pan Tilt Video Sensor Interoperability Attribute provides the capability to configure, control, and find/connect to a video device (analog or digital) that has pan tilt capabilities (i.e. a PTZ camera). The Pan Tilt Video Sensor is a specific instance of a Pan Tilt Interoperability Attribute that applies a Digital Video Sensor Attribute Option or Analog Video Sensor Attribute Option. The Pan Tilt Video Sensor is provided as its own Interoperability Attribute because of its common use as a sensor. A Pan Tilt Video Sensor Interoperability Attribute can be composed of either a Digital or Analog Video Sensor Interoperability Attribute, plus a Basic Pan Tilt Manipulator Interoperability Attribute and any of the Attribute Options that can be applied to Basic Pan Tilt Manipulator Interoperability Attribute. This must be specified as a parameter value for the parameter **[Parameter]** composition (default = Digital Video Sensor Interoperability Attribute, Basic Pan Tilt Manipulator Interoperability Attribute with no Attribute Options added).

4.4.5.1 Component and Service Requirements

The Pan Tilt Video Sensor Interoperability Attribute shall provide one JAUS component that provides all the services of the Manipulator Interoperability Attribute and Sensor Attribute Option that it is composed of.

4.4.5.2 Notes and Interpretations

The intended use of this Interoperability Attribute is for a pan-tilt camera that is one integrated unit (manipulation and video capabilities combined into the same hardware device). A pan-tilt mechanism with an independent camera attached should be specified as a complex payload that aggregates a Digital/Analog Video Interoperability Attribute and a Basic Pan Tilt Manipulator Interoperability Attribute.

4.4.5.3 Periodicity

There are no special periodicity requirements for the Pan Tilt Video Sensor Interoperability Attribute.

4.4.6 Microphone Interoperability Attribute [Selectable, Multiple]

The Microphone Interoperability Attribute provides the capability to receive audio from a microphone device. It is assumed that the audio will be sent in a digital format.

4.4.6.1 Component and Service Requirements

The Microphone Interoperability Attribute shall provide one JAUS component that provides the following services:

Table 4.4-10: Components and Services for Speaker Interoperability Attribute

| Speaker Component | |
|---|--|
| Service | Reference |
| urn tbd:DigitalAudioSensor, version tbd | AEODRS Common Architecture JAUS Extension Services and Experimental Messages |

In addition, the Microphone Interoperability Attribute shall add the following service to the JAUS component defined by the Platform Management Interoperability Attribute (if there is none, a new JAUS component under the Platform JAUS node shall be created). Only a single instance of this service shall be provided – if multiple Interoperability Attributes or Attribute Options are specified that require it, it shall be treated as the same service for all of them.

Table 4.4-11: Components and Services added to Platform Management Interoperability Attribute

| Component Provided by Platform Manager Attribute (new component if value = none) | |
|--|---|
| Service | Reference |
| urn:jaus:iop:DigitalStreamDiscovery, v0.1 | Custom Services, Messages, and Transports |

4.4.6.2 Notes and Interpretations

The SetDigitalAudioStreamEndpoint, QueryDigitalAudioStreamEndpoint, and ReportDigitalAudioStreamEndpoint messages shall not be used.

The following message interpretations apply for the Digital Audio Sensor service:

Table 4.4-12: Message Interpretations for Speaker Attribute

| Message(s) | Concept | Interpretations |
|--------------|------------------------|--|
| All Messages | annunciatorID Field | The primary SensorID (microphone) on a platform shall be assigned an ID of 1. The primary microphone is not explicitly defined, but will likely be a microphone used to communicate for platform-human interactions. All other IDs shall be dynamically assigned in a range of 2 – maximum unsigned short integer. |

4.4.6.3 Periodic Messages

There are no special periodicity requirements for the Microphone Interoperability Attribute.

4.4.7 Lights Interoperability Attribute [Selectable]

If selected, the Lights Interoperability Attribute provides the capability to interact with lights. The Lights Interoperability Attribute is unique and applies only to lights on the platform. The Lights Attribute Option defined in Section 4.7.12 Lights Attribute Option shall be used to add lighting capabilities to something other than the platform.

4.4.7.1 Component and Service Requirements

The Lights Interoperability Attribute shall provide one JAUS component under the Platform JAUS node that provides the following services:

Table 4.4-13: Components and Service for Lights Interoperability Attribute

| Lights Component | |
|--|-----------------------------|
| Service | Reference |
| urn:jaus:jss:ugv:IlluminationService, v0.1 | AS6091 JAUS UGV Service Set |

4.4.7.2 Notes and Interpretations

The following message interpretations apply for the Illumination service:

Table 4.4-14: Message Interpretations for Lights Attribute

| Message(s) | Concept | Interpretations |
|---|--------------------------------|---|
| ID 0513: SetIlluminationState ID 4513: ReportIlluminationState ID 4514: ReportIlluminationConfiguration | IlluminationState bit_field | <ul style="list-style-type: none"> - Headlights – the headlights field will be used to turn on and off vehicle headlights. Headlights are defined as forward facing light or lights used to illuminate the driving path of a vehicle as it moves forward. For vehicles without traditional headlights (i.e. on a smaller platform), this is defined as any non-variable lights associated with the vehicle forward drive camera. - Left Turn Signal – the left turn signal will be used to turn on and off a vehicle's left turn signal. The left turn signal is defined as a visual signal presented to an observer behind the vehicle that indicates the vehicle is about to or is turning left. In the case of a |

Unclassified

| | | |
|--|--|--|
| | | <p>vehicle that has no left turn signal, this field shall be set to 0 indicating off. On may indicate either a solid or blinking on state.</p> <ul style="list-style-type: none">- Right Turn Signal – the right turn signal will be used to turn on and off a vehicle's right turn signal. The right turn signal is defined as a visual signal presented to an observer behind the vehicle that indicates the vehicle is about to or is turning right. In the case of a vehicle that has no right turn signal, this field shall be set to 0 indicating off. On may indicate either a solid or blinking on state.- Running Lights – the running lights field will be used to turn on and off vehicle running lights. Running lights are defined as all lights that are used while a vehicle is running for purposes other than signaling or driving (i.e. lighting for safety).- Brake Lights – the brake lights field will be used to turn on and off vehicle brake lights. Brake lights are defined as rear facing lights used to indicate that a vehicle is applying a resistive linear force in order to slow down. If a vehicle does not have brake lights, this field shall be set to 0 indicating off.- VariableLights – the variable light fields are used to turn on and off lights that have varying intensities, where 0 indicates off and 15 indicates maximum intensity. Values in between shall be mapped to the closest light level the variable light is capable of producing. VariableLight1 shall be used for a variable light source associated with the forward drive camera, and is mutually exclusive with Headlights. VariableLight2 shall be used for a variable light source associated with a rear driving camera. VariableLight3 and VariableLight4 are undefined as of this time.- VisibleLightSource – the VisibleLightSource field shall not be used for the overall vehicle.- IRLightSource – the IRLightSource field will be used to turn on and off an IR light source associated with the currently controlled drive camera |
|--|--|--|

4.4.7.3 Periodic Messages

There are no special periodic message considerations.

4.4.8 Speaker Interoperability Attribute [Selectable]

The Speaker Interoperability Attribute provides the capability to send audio that gets annunciated over a speaker. It is assumed that the audio will be sent in a digital format and converted to an analog signal if required by the speaker.

4.4.8.1 Component and Service Requirements

The Speaker Interoperability Attribute shall provide one JAUS component that provides the following services:

Table 4.4-15: Components and Services for Speaker Attribute

| Speaker Component | |
|--|--|
| Service | Reference |
| urn tbd:DigitalAudioAnnunciator, version tbd | AEODRS Common Architecture JAUS Extension Services and Experimental Messages |

4.4.8.2 Notes and Interpretations

The following message interpretations apply for the Digital Audio Annunciator service:

Table 4.4-16: Message Interpretations for Speaker Attribute

| Message(s) | Concept | Interpretations |
|--|------------------------|---|
| ID EF01: QueryAnnunciatorCapabilities ID FF01: ReportAnnunciatorCapabilities ID EF02: QueryAnnunciatorConfiguration ID FF02: ReportAnnunciatorConfiguration ID DF02: SetAnnunciatorConfiguration ID EF03: QueryAnnunciatorEndpoint ID FF03: ReportAnnunciatorEndpoint | annunciatorID Field | The primary annunciator (speaker) on a platform shall be assigned an ID of 1. The primary speaker not explicitly defined, but will likely be a speaker used to communicate for platform-human interactions. All other IDs shall be dynamically assigned in a range of 2 – maximum unsigned short integer. |

4.4.8.3 Periodic Messages

There are no special periodicity requirements for the Speaker Interoperability Attribute.

4.5 *Actuator and Manipulator Interoperability Attributes and Attribute Options*

Actuator and manipulator Interoperability Attributes are attributes related to actuators and manipulators, and typically deal with common robotics manipulators such as arms and pan tilt units. The following actuator and manipulator Interoperability Attributes and Attribute Options are defined:

Table 4.5-1: Actuator and Manipulator Interoperability Attributes

| Attribute Name | Attribute Values | Description |
|--|-------------------------|--|
| General Actuator Requirements [Mandatory] | Default | Defines basic manipulator requirements and interpretations. |
| Basic Manipulator [Selectable, Multiple] | Default | Defines a basic manipulator controlled using open loop control. Attribute options from the Actuator and Manipulator group can be added to provide closed loop velocity and position control, end effector based control, end effectors, and position and velocity sensing. |

Unclassified

| | | |
|--|---------|--|
| Basic Pan Tilt Manipulator [Selectable, Multiple] | Default | Defines a basic pan tilt manipulator controlled using open loop control. Attribute options from the Actuator and Manipulator group can be added to provide closed loop velocity and position control, and velocity and position sensing. |
| Telescoping Mast [Selectable, Multiple] | Default | Defines a special case of Basic Manipulator that represents a mast that translates along one axis. |

Table 4.5-2: Actuator and Manipulator Attribute Options

| Attribute Option Name | Description |
|--|--|
| Advanced Manipulator | Adds the capability to “fly the end effector” using closed loop position control and reporting of an end effector. |
| Pan Tilt Manipulator Position Control | Adds the capability to control a pan tilt manipulator using closed loop position control. |
| Pan Tilt Manipulator Velocity Control | Adds the capability to control a pan tilt manipulator using closed loop velocity control. |
| Pan Tilt Manipulator Velocity Sensor | Adds the capability to get velocity information for a pan tilt manipulator. |
| Pan Tilt Manipulator Position Sensor | Adds the capability to get position information for a pan tilt manipulator. |
| Manipulator Joint Velocity Control | Adds the capability to control manipulator joints using closed loop velocity control. |
| Manipulator Joint Position Control | Adds the capability to control manipulator joints using closed loop position control. |
| Manipulator Joint Velocity Sensor | Adds the capability to get velocity information for manipulator joints. |
| Manipulator Joint Position Sensor | Adds the capability to get position information for manipulator joints. |
| Manipulator End Effector Velocity Control | Adds the capability to “fly the end effector” using closed loop velocity commands. |
| Manipulator End Effector Velocity State Sensor | Adds the capability to get information on the velocity of the end effector. |
| Basic End Effector | Adds a basic end effector capability, representing a simple gripper. |

4.5.1 General Actuator Requirements Interoperability Attribute [Mandatory]

This attribute is mandatory whenever any type of manipulator, pan tilt, or telescoping mast is specified. Actuators are defined as devices that have linkages that move around or translate about joints. Capabilities Provided To All Actuators/Manipulator Attributes

The general capabilities for querying and reporting the type of manipulator are provided by using the QueryManipulatorSpecifications and ReportManipulatorSpecifications messages and using the record type (revolute or prismatic) to determine the type of manipulator. This applies to all manipulator attributes that specify these messages. The type of actuator is implied for the Basic Pan Tilt, Advanced Pan Tilt, and Telescoping Mast Interoperability Attributes. The following message interpretations apply for the QueryManipulatorSpecifications and ReportManipulatorSpecifications messages, which are provided by many of the manipulator services:

Table 4.5-3: Message Interpretations for Actuators/Manipulators

| Message(s) | Concept | Interpretations |
|---|-------------|--|
| ID 2600: QueryManipulatorSpecifications ID 4600: ReportManipulatorSpecifications | Usage | The ManipulatorCoordinateSystemRec shall be included unless the manipulator service handling Query Manipulator Specification responses is not aware of the position of the manipulator base on the platform. |
| | Joint Types | Each revolute (rotation) and prismatic (translation) joint contained in the manipulator shall be included using the appropriate records according to <i>AS6057 JAUS Manipulator Service Set</i> . This includes maximum and minimum joint angles or offsets (Query/Report limits), the total number of joints (Query/Report degrees of freedom), and the types of joints (prismatic or revolute) |

4.5.1.1 Actuator/Manipulator Drive Timeouts

All actuators and manipulators that use either effort based or velocity based control of joints and/or other parts of the manipulator shall define values for drive timeout parameters similar to those in Section 4.3.2 Drive Timeout Interoperability Attribute [Mandatory]. These values shall specify the maximum amount of time between manipulator drive messages (i.e. SetJointEffort) to the manipulator before the manipulator is stopped. These values should be based on the capabilities and characteristics of the manipulator or actuator. Once a drive timeout has occurred, the actuator/manipulator shall stay in a stopped state until manipulator drive messages are received again for a specified amount of time at a specified minimum rate. To meet the actuator/manipulator drive timeout requirements, values must be specified for the following parameters (Figure 4.3-1 applies, except the transition are based on manipulator drive messages instead of platform drive messages):

- **[Parameter]** Drive Timeout time (default = 1 second) – The time after receiving the last drive message (i.e. SetJointEffort) at which a Drive Timeout is considered to occur.
- **[Parameter]** Drive Frequency (default = None) - The frequency and acceptable variation at which drive messages must be received. If this frequency is not maintained, a Drive Timeout is considered to occur.
- **[Parameter]** Drive Recovery time (default = 1 second) – The amount of time over which drive messages must be received at the specified Drive Frequency before transitioning out of a Drive Timeout state to a Normal Drive state.

4.5.2 Basic Manipulators Interoperability Attribute [Selectable, Multiple]

Basic manipulators are the most simplistic manipulators defined by the IOP that contain support for primitive actuation. Basic manipulators provide open loop control of manipulator joints.

4.5.2.1 Component and Service Requirements

The Basic Manipulator Interoperability Attribute provides a JAUS component that provides the following services:

Table 4.5-4: Components and Services for Basic Manipulators Attribute

| Basic Manipulator Component | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:PrimitiveManipulator, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.2.2 Notes and Interpretations

There are no notes or interpretations for the Basic Manipulator Interoperability Attribute.

4.5.2.3 Periodicity

ID 0601: SetJointEffort – Sending of the SetJointEffort message shall comply with the manipulator drive timeout requirements defined in Section 4.5.1.1 Actuator/Manipulator Drive Timeouts.

4.5.3 Basic Pan Tilt Manipulator Interoperability Attribute [Selectable, Multiple]

Basic pan tilt manipulators are a specific type of manipulator designed for panning and tilting, typically with a device attached such as a camera. The Basic Pan Tilt Manipulator Interoperability Attribute defines the capability for interacting with a Pan Tilt manipulator in a simple open-loop fashion.

4.5.3.1 Component and Service Requirements

The Basic Pan Tilt Manipulator Interoperability Attribute provides one JAUS component that provides the following services:

Table 4.5-5: Components and Services for Basic Pan Tilt Manipulator Interoperability Attribute

| Basic Pan Tilt Manipulator Component | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:PrimitivePanTilt, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.3.2 Notes and Interpretations

The following message interpretations apply for the Primitive Pan Tilt Manipulator service:

Table 4.5-6: Message Interpretations for Basic Pan Tilt Manipulator Attribute

| Message(s) | Concept | Interpretations |
|--------------------------------|----------------|---|
| ID 0621: SetPanTiltJointEffort | Usage | Joint1Effort is the “pan” and Joint2Effort is the “tilt”. |

4.5.3.3 Periodicity

ID 0621: SetPanTiltJointEffort - Sending of the SetPanTiltJointEffort message shall comply with the manipulator drive timeout requirements defined in Section 4.5.1.1 Actuator/Manipulator Drive Timeouts.

4.5.4 Telescoping Mast Interoperability Attribute [Selectable, Multiple]

A Telescoping Mast is a component that is a specific type of Basic Manipulator with the following restrictions:

Unclassified

- A Telescoping Mast is a manipulator with a single prismatic joint and no other joints – the Telescoping Mast goes back and forth along the Telescoping Mast axis of motion, where a value of 0 indicates the Telescoping Mast is fully retracted and there is some maximum value that corresponds to the limit that the Telescoping Mast can extend to. See Figure 4.5-1: Telescoping Mast Example.
- The Report Manipulator Specifications message shall always report a single Prismatic Joint with a Min value (in the PrismaticJointAngleRec) of 0 and a maximum value that is equivalent to the maximum extension of the Telescoping Mast.

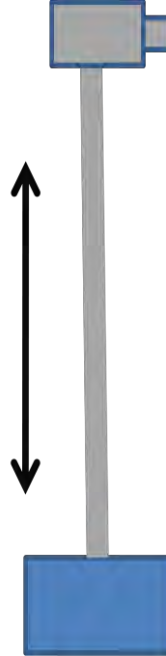


Figure 4.5-1: Telescoping Mast Example

4.5.5 Advanced Manipulator Attribute Option

The Advanced Manipulator Attribute Option extends the capabilities of the Basic Manipulator attribute by adding support for control of the manipulator through specifying end effector pose.

4.5.5.1 Valid Attribute Values

- Actuators and Manipulators::Basic Manipulator::Default

4.5.5.2 Component and Service Requirements

The Advanced Manipulator Attribute Option shall add the following services to a Basic Manipulator JAUS component:

Table 4.5-7: Components and Services for Advanced Manipulator Attribute Option

| Basic Manipulator Component (added to) | |
|--|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:ManipulatorEndEffectorPoseDriver, v1.0 | AS6057 JAUS Manipulator Service Set |
| urn:jaus:jss:manipulator:ManipulatorEndEffectorPoseListDriver, v 1.0 | AS6057 JAUS Manipulator Service Set |
| urn:jaus:jss:manipulator:ManipulatorEndEffectorPoseSensor, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.5.3 Notes and Interpretations

The following message interpretations apply for all services that define the message:

Table 4.5-8: Message Interpretations for Advanced Manipulator Attribute option

| Message(s) | Concept | Interpretations |
|---|----------------|--|
| ID 0604: SetToolOffset | Usage | <ul style="list-style-type: none"> - If there is no tool other than a simple gripper, this message shall have no meaning. - Interpretation of this message for other end effectors (i.e. cutters, excavators, etc.) is reserved for later versions of this document. |
| ID 0607: SetJointMotionProfile | Usage | The SetJointMotionProfile message should be used to set maximum speeds, accelerations, and decelerations for joints based on specific safety requirements for their operation. |
| ID 2610: QueryCommandedEndEffectorPose ID 4610: ReportCommandedEndEffectorPose | Usage | The actual pose of the manipulator and the pose reported by this message pair are not guaranteed to be the same. |
| ID 261E: QueryActiveElement ID 461E: ReportActiveElement | Usage | The pose derived from the active element is not guaranteed to be the actual pose. |

4.5.5.4 Periodicity

There are no special periodicity requirements for the Advanced Manipulator Attribute Option.

4.5.6 Pan Tilt Manipulator Velocity Control Attribute Option

The Pan Tilt Manipulator Velocity Control Attribute Option adds the capability to perform closed loop velocity based control to a Basic Pan Tilt Manipulator Interoperability Attribute.

4.5.6.1 Valid Attribute Values

- Actuators and Manipulators::Basic Pan Tilt Manipulator::Default

4.5.6.2 Component and Service Requirements

The Pan Tilt Manipulator Velocity Control Attribute Option adds the following services to the JAUS component provided by the Basic Pan Tilt Manipulator Interoperability Attribute:

Table 4.5-9: Components and Services for Pan Tilt Manipulator Velocity Control Attribute Option

| Basic Pan Tilt Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:PanTiltJointVelocityDriver, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.6.3 Notes and Interpretations

The following message interpretations apply for the Pan Tilt Joint Velocity Driver service:

Table 4.5-10: Message Interpretations for Pan Tilt Manipulator Velocity Control Attribute Option

| Message(s) | Concept | Interpretations |
|---|----------------|---|
| ID 4631: ReportCommandedPanTiltJointVelocity | Usage | - Joint1Velocity is the “pan” joint velocity, and Joint2Velocity is the “tilt” joint velocity. - The commanded pan tilt joint velocity is not guaranteed to be the same as the actual pan tilt joint velocity. |
| ID 0623: SetPanTiltJointVelocity | Usage | - Joint1Velocity is the “pan” joint velocity, and Joint2Velocity is the “tilt” joint velocity. |

4.5.6.4 Periodicity

ID 0623: SetPanTiltJointVelocity - Sending of the SetPanTiltJointVelocity message shall comply with the manipulator drive timeout requirements defined in Section 4.5.1.1 Actuator/Manipulator Drive Timeouts.

4.5.7 Pan Tilt Manipulator Position Control Attribute Option

The Pan Tilt Manipulator Position Control Attribute Option adds the capability to perform closed loop position based control to a Basic Pan Tilt Manipulator Interoperability Attribute.

4.5.7.1 Valid Attribute Values

- Actuators and Manipulators::Basic Pan Tilt Manipulator::Default

4.5.7.2 Component and Service Requirements

The Pan Tilt Manipulator Position Control Attribute Option adds the following services to the JAUS component provided by the Basic Pan Tilt Manipulator Interoperability Attribute:

Table 4.5-11: Components and Services for Pan Tilt Manipulator Position Control Attribute Option

| Basic Pan Tilt Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:PanTiltJointPositionDriver, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.7.3 Notes and Interpretations

The following message interpretations apply for the Pan Tilt Joint Position Driver service:

Table 4.5-12: Message Interpretations for Pan Tilt Manipulator Position Control Attribute

| Message(s) | Concept | Interpretations |
|---|---------|---|
| ID 4628: ReportCommandedPanTiltJointPosition | Usage | - Joint1Position is the “pan” joint position, and Joint2Position is the “tilt” joint position. - The commanded pan tilt joint position is not guaranteed to be the same as the actual pan tilt joint position. |
| ID 0622: SetPanTiltJointPosition | Usage | - Joint1Position is the “pan” joint position, and Joint2Position is the “tilt” joint position. |

4.5.7.4 Periodicity

There are no special periodicity requirements for the Pan Tilt Manipulator Position Control Attribute Option.

4.5.8 Pan Tilt Manipulator Velocity Sensor Attribute Option

The Pan Tilt Manipulator Velocity Sensor Attribute Option adds the capability to get pan tilt manipulator joint velocities to a Basic Pan Tilt Manipulator Interoperability Attribute.

4.5.8.1 Valid Attribute Values

- Actuators and Manipulators::Basic Pan Tilt Manipulator::Default

4.5.8.2 Component and Service Requirements

The Pan Tilt Manipulator Velocity Sensor Attribute Option adds the following services to the component provided by the Basic Pan Tilt Manipulator Interoperability Attribute:

Table 4.5-13: Components and Services for Pan Tilt Manipulator Velocity Sensor Attribute Option

| Basic Pan Tilt Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:PanTiltJointVelocitySensor, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.8.3 Notes and Interpretations

The following message interpretations apply for the Pan Tilt Joint Velocity Sensor service:

Table 4.5-14: Message Interpretations for Pan Tilt Manipulator Velocity Sensor Attribute Option

| Message(s) | Concept | Interpretations |
|-------------------------------------|---------|--|
| ID 4623: ReportPanTiltJointVelocity | Usage | - Joint1Velocity is the “pan” joint velocity, and Joint2Velocity is the “tilt” joint velocity. |

4.5.8.4 Periodicity

There are no special periodicity requirements for the Pan Tilt Manipulator Velocity Sensor Attribute Option.

4.5.9 Pan Tilt Manipulator Position Sensor Attribute Option

The Pan Tilt Manipulator Position Sensor Attribute Option adds the capability to get pan tilt manipulator joint positions to a Basic Pan Tilt Manipulator Interoperability Attribute.

4.5.9.1 Valid Attribute Values

- Actuators and Manipulators::Basic Pan Tilt Manipulator::Default

4.5.9.2 Component and Service Requirements

The Pan Tilt Manipulator Position Sensor Attribute Option adds the following services to the JAUS component provided by the Basic Pan Tilt Manipulator Interoperability Attribute:

Table 4.5-15: Components and Services for Pan Tilt Manipulator Position Sensor Attribute Option

| Basic Pan Tilt Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:PanTiltJointPositionSensor, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.9.3 Notes and Interpretations

The following message interpretations apply for the Pan Tilt Joint Position Sensor service:

Table 4.5-16: Message Interpretations for Pan Tilt Manipulator Position Sensor Attribute Option

| Message(s) | Concept | Interpretations |
|-------------------------------------|---------|--|
| ID 4622: ReportPanTiltJointPosition | Usage | - Joint1Position is the “pan” joint position, and Joint2Position is the “tilt” joint position. |

4.5.9.4 Periodicity

There are no special periodicity requirements for the Pan Tilt Manipulator Position Sensor attribute option.

4.5.10 Manipulator Joint Velocity Control Attribute Option

The Manipulator Joint Velocity Control Attribute Option is an option to add closed loop velocity control of manipulator joints to the Basic Manipulator Interoperability Attribute.

4.5.10.1 Valid Attribute Values

- Actuators and Manipulators::Basic Manipulator::Default
- Actuators and Manipulators::Telescoping Mast::Default

4.5.10.2 Component and Service Requirements

The Manipulator Joint Velocity Control Attribute Option adds the following services to the JAUS component provided by the Basic Manipulator Interoperability Attribute:

Table 4.5-17: Components and Services for Manipulator Joint Velocity Control Attribute Option

| Basic Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:ManipulatorJointVelocityDriver, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.10.3 Notes and Interpretations

The following message interpretations apply for the Manipulator Joint Velocity Driver service:

Table 4.5-18: Message Interpretations for Manipulator Joint Velocity Control Attribute Option

| Message(s) | Concept | Interpretations |
|---|---------|---|
| ID 2603: QueryCommandedJointVelocity ID 4603: ReportCommandedJointVelocity | Usage | - The actual velocities of the joints of the manipulator and the velocities of the joints reported by this message pair are not guaranteed to be the same |

4.5.10.4 Periodicity

ID 0603: SetJointVelocity - Sending of the SetJointVelocity message shall comply with the manipulator drive timeout requirements defined in 4.5.1.1 Actuator/Manipulator Drive Timeouts.

4.5.11 Manipulator Joint Position Control Attribute Option

The Manipulator Joint Position Control Attribute Option is an option to add closed loop position control of manipulator joints to the Basic Manipulator Interoperability Attribute.

4.5.11.1 Valid Attribute Values

- Actuators and Manipulators::Basic Manipulator::Default
- Actuators and Manipulators::Telescoping Mast::Default

4.5.11.2 Component and Service Requirements

The Manipulator Joint Position Control Attribute Option adds the following services to the JAUS component provided by the Basic Manipulator Interoperability Attribute:

Table 4.5-19: Components and Services for Manipulator Joint Position Control Attribute Option

| Basic Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:ManipulatorJointPositionDriver, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.11.3 Notes and Interpretations

The following message interpretations apply for the Manipulator Joint Position Driver service:

Table 4.5-20: Message Interpretations for Manipulator Joint Position Control Attribute Option

| Message(s) | Concept | Interpretations |
|---|---------|---|
| ID 2608: QueryCommandedJointVelocity ID 4608: ReportCommandedJointVelocity | Usage | - The actual positions of the joints of the manipulator and the positions of the joints reported by this message pair are not guaranteed to be the same |

4.5.11.4 Periodicity

There are no special periodicity requirements for the Manipulator Joint Position Control Attribute Option.

4.5.12 Manipulator Joint Velocity Sensor Attribute Option

The Manipulator Joint Velocity Sensor Attribute Option is an option to add velocity sensing capability for manipulator joints to the Basic Manipulator Interoperability Attribute.

4.5.12.1 Valid Attribute Values

- Actuators and Manipulators::Basic Manipulator::Default
- Actuators and Manipulators::Telescoping Mast::Default

4.5.12.2 Component and Service Requirements

The Manipulator Joint Velocity Sensor Attribute Option adds the following services to the JAUS component provided by the Basic Manipulator Interoperability Attribute:

Table 4.5-21: Components and Services for Manipulator Joint Velocity Sensor Attribute Option

| Basic Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:ManipulatorJointVelocitySensor, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.12.3 Notes and Interpretations

There are no notes or interpretations for the Manipulator Joint Velocity Sensor Attribute Option.

4.5.12.4 Periodicity

There are no special periodicity requirements for the Manipulator Joint Velocity Sensor Attribute Option.

4.5.13 Manipulator Joint Position Sensor Attribute Option

The Manipulator Joint Position Sensor Attribute Option is an option to add position sensing capability for manipulator joints to the Basic Manipulator Interoperability Attribute.

4.5.13.1 Valid Attribute Values

- Actuators and Manipulators::Basic Manipulator::Default
- Actuators and Manipulators::Telescoping Mast::Default

4.5.13.2 Component and Service Requirements

The Manipulator Joint Position Sensor Attribute Option adds the following services to the JAUS component provided by the Basic Manipulator Interoperability Attribute:

Table 4.5-22: Components and Services for Manipulator Joint Position Sensor Attribute Option

| Basic Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:ManipulatorJointPositionSensor, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.13.3 Notes and Interpretations

There are no notes or interpretations for the Manipulator Joint Velocity Sensor Attribute Option.

4.5.13.4 Periodicity

There are no special periodicity requirements for the Manipulator Joint Velocity Sensor Attribute Option.

4.5.14 Manipulator End Effector Velocity Control Attribute Option

The Manipulator End Effector Velocity Control Attribute Option is an option to add closed loop velocity control of an end effector (fly-the-end-effector) to the Basic Manipulator Interoperability Attribute.

4.5.14.1 Valid Attribute Values

- Actuators and Manipulators::Basic Manipulator::Default
- Actuators and Manipulators::Telescoping Mast::Default

4.5.14.2 Component and Service Requirements

The Manipulator End Effector Velocity Control Attribute Option adds the following services to the JAUS component provided by the Basic Manipulator Interoperability Attribute:

Table 4.5-23: Components and Services for Manipulator End Effector Velocity Control Attribute Option

| Basic Manipulator Component (added to) | |
|--|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:ManipulatorEndEffectorVelocityStateDriver, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.14.3 Notes and Interpretations

The following message interpretations apply for the Manipulator End Effector Velocity State Driver service:

Table 4.5-24: Message Interpretations for Manipulator End Effector Velocity Control Attribute Option

| Message(s) | Concept | Interpretations |
|---|---------|--|
| ID 2612: QueryCommandedEndEffectorVelocityState ID 4612: ReportCommandedEndEffectorVelocityState | Usage | - The actual velocities of the end effector and the velocities of the end effector reported by this message pair are not guaranteed to be the same. |
| ID 0604: SetToolOffset | Usage | - If there is no tool other than a simple gripper, this message shall have no meaning. - Interpretation of this message for other end effectors (i.e. cutters, excavators, etc.) is reserved for later versions of this document. |

4.5.14.4 Periodicity

ID 0603: SetEndEffectorVelocityState - Sending of the SetEndEffectorVelocityState message shall comply with the manipulator drive timeout requirements defined in 4.5.1.1 Actuator/Manipulator Drive Timeouts.

4.5.15 Manipulator End Effector Velocity State Sensor Attribute Option

The Manipulator End Effector Velocity State Sensor Attribute Option is an option to add end-effector velocity sensing capability to the Basic Manipulator Interoperability Attribute.

4.5.15.1 Valid Attribute Values

- Actuators and Manipulators::Basic Manipulator::Default
- Actuators and Manipulators::Telescoping Mast::Default

4.5.15.2 Component and Service Requirements

The Manipulator End Effector Velocity State Sensor Attribute Option adds the following services to the JAUS component provided by the Basic Manipulator Interoperability Attribute:

Table 4.5-25: Components and Services for Manipulator End Effector Velocity State Sensor Attribute Option

| Basic Manipulator Component (added to) | |
|--|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:ManipulatorEndEffectorVelocityStateSensor, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.15.3 Notes and Interpretations

There are no notes or interpretations for the Manipulator End Effector Velocity State Sensor Attribute Option.

4.5.15.4 Periodicity

There are no special periodicity requirements for the Manipulator End Effector Velocity State Sensor Attribute Option.

4.5.16 Basic End Effector Attribute Option

The Basic End Effector Attribute Option is an option to add a simple one degree of freedom end effector (i.e. a basic two fingered gripper) to a Basic Manipulator Interoperability Attribute. Currently, only a simple gripper end effector is supported by this Attribute Option – the behaviors for more advanced end effector types (such as cutters or excavators) shall be provided in later versions of this document.

4.5.16.1 Valid Attribute Values

- Actuators and Manipulators::Basic Manipulator::Default

4.5.16.2 Component and Service Requirements

The Basic End Effector Attribute Option adds the following services to the JAUS component provided by the Basic Manipulator Interoperability Attribute:

Table 4.5-26: Components and Services for Basic End Effector Attribute Option

| Basic Manipulator Component (added to) | |
|---|-------------------------------------|
| Service | Reference |
| urn:jaus:jss:manipulator:PrimitiveEndEffector, v1.0 | AS6057 JAUS Manipulator Service Set |

4.5.16.3 Notes and Interpretations

The following message interpretations apply for the Primitive End Effector service:

Table 4.5-27: Message Interpretations for Basic End Effector Attribute Option

| Message(s) | Concept | Interpretations |
|---|---------------------------|--|
| ID 2632: QueryEndEffectorSpecification ID 4632: ReportEndEffectorSpecification | Usage | - ParentID shall be the JAUS identifier of the Basic Manipulator component that the end effector is attached to |
| 0633: SetEndEffectorEffort | Gripper Type End Effector | - When applied to a gripper type end effector, a positive value indicates the gripper is closing, and a negative value indicates the gripper is opening. |
| | Other End Effector Types | The behaviors for extra end effector types will be provided in later versions of this document. |

4.5.16.4 Periodicity

ID 0633: SetEndEffectorEffort - Sending of the SetEndEffectorEffort message shall comply with the manipulator drive timeout requirements defined in Section 4.5.1.1 Actuator/Manipulator Drive Timeouts.

4.6 *Communications Interoperability Attributes and Attribute Options*

Communications Interoperability Attributes and Attribute Options define capabilities to deal with communications off-board the platform. This is typically through a communications link such as a radio, but may include other forms of communications. The following communications Interoperability Attributes are defined:

Table 4.6-1: Communications Interoperability Attributes

| Attribute Name | Attribute Values | Description |
|---|------------------|---|
| Communicator [Selectable, Multiple] | Default | Defines a capability to interact with a communications device, such as a radio, including configuring it. |

4.6.1 Communicator Interoperability Attribute [Selectable, Multiple]

If selected, the Communicator Interoperability Attribute provides a mechanism for run-time configuration and monitoring of a communication link, usually a radio, through a Communicator service. Multiple instances of the Communicator attribute may be specified, with each instance corresponding to a single communication link.

4.6.1.1 Component and Service Requirements

The Communicator Interoperability Attribute shall provide a Communicator JAUS component that serves the following services:

Table 4.6-2: Components and Services for the Communicator Interoperability Attribute

| Communicator Component | |
|---------------------------------------|---|
| Service | Reference |
| urn:jaus:jpo:comms:Communicator, v1.0 | Custom Services, Messages, and Transports |

4.6.1.2 Notes and Interpretations

There are no notes or interpretations for the Communicator Interoperability Attribute.

4.6.1.3 Periodicity

There are no special periodicity requirements for the Communicator Interoperability Attribute.

4.7 *Global Interoperability Attributes and Attribute Options*

Global Interoperability Attributes are attributes that do not tightly fit into a single attribute group. For example, the Capability attribute can define a component that aggregates services from any and all of the attribute groupings.

Global attribute options are attribute options that can be applied to attributes across more than one attribute category. For example, a Global Pose Sensor Attribute Option might be added to a JAUS component on the Platform JAUS node for an IMU integrated on the platform, or could be added to a JAUS component of a complex payload to represent an IMU that comes with an autonomy package.

Global Interoperability Attributes and Attribute Options are members of the Global attribute and attribute option group.

Table 4.7-1: Global Attributes

| Attribute Name | Attribute Values | Description |
|--|-------------------------|--|
| Node [Selectable, Multiple, Aggregator] | Default | Provides the capability to aggregate attributes providing JAUS components onto a single JAUS node. |
| Capability [Selectable, Multiple, Composed] | Default | Allows for defining a capability (JAUS component). |

Table 4.7-2: Global Attribute Options

| Attribute Option Name | Description |
|------------------------------|---|
| Global Position and Attitude | Adds the capability to report global position and attitude. |
| Local Position and Attitude | Adds the capability to report local position and attitude. |
| Acceleration State Sensor | Adds the capability to report acceleration state information. |
| Velocity State Sensor | Adds the capability to report velocity state information. |
| Digital Video | Adds the capability to control and configure digital video, as well as find a |

Unclassified

| | |
|-----------------|--|
| | digital video stream. Typically associated with a single camera, but may be associated with a fused video source or simulated video as well. |
| Still Image | Adds the capability to control and configure a still image source. |
| Range Finder | Adds the capability to configure and get information from a range finder sensor, such as a LADAR or RADAR. |
| Analog Video | Adds the capability to control and configure an analog video source. |
| Microphone | Adds the capability to get information from a sound input device (microphone). |
| Lights | Adds the capability to find and configure lights. |
| Speaker | Adds the capability to interact with a sound output device (a speaker). |
| Health Reporter | Adds low level health reporting capabilities. |

4.7.1 Node Interoperability Attribute [Selectable, Multiple, Aggregator]

The Node Interoperability Attribute is a special attribute that allows multiple existing Interoperability Attributes to be aggregated together. The following parameters must be defined for the default Value of the Node Interoperability Attribute:

- **[Parameter] Name** (Default = none) – Defines the name of the node.
- **[Parameter] ID** (Default = none) – Specifies the JAUS node ID of the node provided by this attribute. If this parameter is left as none, assignment based on Section 4.1.3 ID Assignment Interoperability Attribute [Mandatory, Mutually Exclusive] is performed.
- **[Parameter] Aggregated Attributes** (Default = none) – A list of attributes that are aggregated using this Node attribute. Only attributes that provide a component may be listed here.

4.7.2 Capability Interoperability Attribute [Selectable, Multiple, Composed]

The Capability Interoperability Attribute is used to define a JAUS component (the Capability component) to which Attribute Options and Interoperability Attributes add service to. This is done by composing the Capability Interoperability Attribute of other attributes and adding Attribute Options. Three parameters shall be specified as part of this attribute:

- **[Parameter] Attribute List** (default = none) – this parameter shall list all Interoperability Attributes that the capability attribute's component is composed of. Being composed of an attribute means that the services defined by that attribute are added to the JAUS component for the Capability. Any duplicated services shall be presented to a client of the Capability component as a single service.
- **[Parameter] Attribute Option List** (default = none) – this parameter shall list all Attribute Options that are added to this attribute. Only attribute options that list Global::Capability::Default in their valid attribute values may be added to this list.
- **[Parameter] Name** (default = none) – this names the capability and the component that it provides. I.e. a name of "Position Sensing" implies a Position Sensing component is provided.

4.7.3 Global Position and Attitude Attribute Option

The Global Position and Attitude Attribute Option allows the addition of a global positioning sensing capability to an Interoperability Attribute. This global position is typically obtained from a Global Positioning Sensor (GPS), but may also be a combination of multiple sensor modalities that lead to a global pose referenced using WGS 84.

4.7.3.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.3.2 Component and Service Requirements

The Global Position and Attitude Attribute Option adds the following services to a component defined by the attribute the option is added to:

Table 4.7-3: Components and Services for Global Position and Attitude Attribute Option

| Component (added to) | |
|--|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:GlobalPoseSensor, v1.0 | AS6009 JAUS Mobility Service Set |

4.7.3.3 Notes and Interpretations

There are no notes or interpretations for the Global Position and Attitude Attribute Option.

4.7.3.4 Periodicity

- ID 4402: ReportGlobalPose – **[Parameter] Report Rate** (Default = 1 Hz) – The report rate parameter defines the minimum rate at which the Global Pose Sensor must be able to send Report Global Pose messages, either through a periodic Event (urn:jaus:jss:core:events) or by responding to regularly sent QueryGlobalPose messages. This parameter should be defined to allow for safe operation of the platform.

4.7.4 Local Position and Attitude Attribute Option

The Local Position and Attitude Attribute Option allows the addition of a local positioning sensing capability to an Interoperability Attribute. This local position is usually referenced to a (0, 0) starting point of the platform, and updated utilizing sensor such as wheel encoders, IMUs, etc.

4.7.4.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.4.2 Component and Service Requirements

The Local Position and Attitude Attribute Option adds the following services to a JAUS component defined by the Interoperability Attribute the option is added to:

Table 4.7-4: Components and Services for Local Pose and Attitude Attribute Option

| Component (added to) | |
|---|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:LocalPoseSensor, v1.0 | AS6009 JAUS Mobility Service Set |

4.7.4.3 Notes and Interpretations

There are no notes or interpretations for the Global Position and Attitude Attribute Option.

4.7.4.4 Periodicity

- ID 4403: ReportLocalPose – **[Parameter] Report Rate** (Default = 1 Hz) – The report rate parameter defines the minimum rate at which the Local Pose Sensor must be able to send Report Local Pose messages, either through a periodic Event (urn:jaus:jss:core:events) or by responding to regularly sent QueryLocalPose messages. This parameter should be defined to allow for safe operation of the platform.

4.7.5 Acceleration State Sensor Attribute Option

The Acceleration State Sensor Attribute Option allows the addition of acceleration state sensing capability to an Interoperability Attribute. This acceleration state may come from a sensor such as an IMU.

4.7.5.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.5.2 Component and Service Requirements

The Acceleration State Sensor Attribute Option shall add the following services to a component provided by an Interoperability Attribute the option is added to.

Table 4.7-5: Components and Services for Acceleration State Sensor Attribute Option

| Component (added to) | |
|---|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:AccelerationStateSensor, v1.0 | AS6009 JAUS Mobility Service Set |

4.7.5.3 Notes and Interpretations

There are no notes or interpretations for the Acceleration State Sensor Attribute Option.

4.7.5.4 Periodicity

There are no special periodicity requirements for the Acceleration State Sensor Attribute Option.

4.7.6 Velocity State Sensor Attribute Option

The Velocity State Sensor Attribute Option allows the addition of velocity state sensing capability to an Interoperability Attribute.

4.7.6.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.6.2 Component and Service Requirements

The Velocity State Sensor Attribute Option shall add the following services to a component provided by an Interoperability Attribute the option is added to.

| Component (added to) | |
|---|----------------------------------|
| Service | Reference |
| urn:jaus:jss:mobility:VelocityStateSensor, v1.0 | AS6009 JAUS Mobility Service Set |

4.7.6.3 Notes and Interpretations

There are no notes or interpretations for the Velocity State Sensor Attribute Option.

4.7.6.4 Periodicity

There are no special periodicity requirements for the Velocity State Sensor Attribute Option.

4.7.7 Digital Video Attribute Option

The Digital Video Attribute Option may be added to any valid attribute Value to have it provide digital video capabilities. The Interoperability Attribute this option is added to must provide a JAUS component.

4.7.7.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default (except for Digital Video attribute)
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.7.2 Component and Service Requirements

The Digital Video Attribute Option adds the following services to any Interoperability Attribute that provides a JAUS component:

Table 4.7-6: Components and Services for Digital Video Attribute Option

| Component (added to) | |
|--|---|
| Service | Reference |
| urn:jaus:jss:environmentSensing;DigitalVideo, v1.0 | AS6060 JAUS Environment Sensing Service Set |

In addition, the Digital Video Attribute Option shall add the following service to the JAUS component defined by the Platform Management Interoperability Attribute (if there is none, a new JAUS component under the Platform JAUS node shall be created). Only a single instance of this service shall be provided – if multiple attributes or attribute options are specified that require it, it shall be treated as the same service for all of them.

Table 4.7-7: Components and Service added to Platform Management Interoperability Attribute

| Component Provided by Platform Manager Attribute (new component if value = none) | |
|---|---|
| Service | Reference |
| urn:jaus:iop:DigitalStreamDiscovery, v0.1 | Custom Services, Messages, and Transports |

4.7.7.3 Notes and Interpretations

See Section 4.4.1.2 Notes and Interpretations within Section 4.4.1 Digital Video Interoperability Attribute [Selectable, Multiple] for notes and interpretations.

4.7.7.4 Periodicity

There are no special periodicity requirements for the Digital Video Attribute Option.

4.7.8 Still Image Attribute Option

The Still Image Attribute Option may be added to any valid Interoperability Attribute Value to have it provide still image capabilities. The attribute this option is added to must provide a JAUS component.

4.7.8.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default (except for Still Image attribute)
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.8.2 Component and Service Requirements

The Still Image Attribute Option adds the following services to any Interoperability Attribute that provides a JAUS component:

Table 4.7-8: Components and Services for Still Image Attribute Option

| Component (added to) | |
|--|---|
| Service | Reference |
| urn:jaus:jss:environmentSensing;StillImage, v1.0 | AS6060 JAUS Environment Sensing Service Set |

4.7.8.3 Notes and Interpretations

See Section 4.4.2.2 Notes and Interpretations of Section 4.4.2 Still Image Interoperability Attribute [Selectable, Multiple] for notes and interpretations.

4.7.8.4 Periodicity

There are no special periodicity requirements for the Still Image Attribute Option.

4.7.9 Range Finder Attribute Option

The Range Finder Attribute Option may be added to any valid Interoperability Attribute Value to have it provide range finder capabilities. The Interoperability Attribute this option is added to must provide a JAUS component.

4.7.9.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default (except for Range Finder attribute)
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.9.2 Component and Service Requirements

The Range Finder Attribute Option adds the following services to any attribute that provides a JAUS component:

Table 4.7-9: Components and Services for Range Finder Attribute Option

| Component (added to) | |
|---|---|
| Service | Reference |
| urn:jaus:jss:environmentSensing;RangeSensor, v1.0 | AS6060 JAUS Environment Sensing Service Set |

4.7.9.3 Notes and Interpretations

See Section 4.4.3.2 Notes and Interpretations of Section 4.4.3 Range Finder Interoperability Attribute [Selectable, Multiple] for notes and interpretations.

4.7.9.4 Periodicity

There are no special periodicity requirements for the Range Finder Attribute Option.

4.7.10 Analog Video Attribute Option

The Analog Video Attribute Option may be added to any valid Interoperability Attribute Value to have it provide analog video capabilities. The Interoperability Attribute this option is added to must provide a JAUS component.

4.7.10.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default (except for Analog Video attribute)
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.10.2 Component and Service Requirements

The Analog Video Attribute Option adds the following services to any attribute that provides a JAUS component:

Table 4.7-10: Components and Services for Analog Video Attribute Option

| Component (added to) | |
|---|---|
| Service | Reference |
| urn:jaus:jss:environmentSensing;AnalogVideo, v1.0 | AS6060 JAUS Environment Sensing Service Set |

4.7.10.3 Notes and Interpretations

See Section 4.4.4.2 Notes and Interpretations of Section 4.4.4 Analog Video Interoperability Attribute [Selectable, Multiple] for notes and interpretations.

4.7.10.4 Periodicity

There are no special periodicity requirements for the Analog Video Attribute Option.

4.7.11 Microphone Attribute Option

The Microphone Attribute Option adds the capabilities to receive audio from a microphone device. It is assumed that the audio will be sent in a digital format.

4.7.11.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default

- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default (except for Microphone attribute)
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.11.2 Component and Service Requirements

The Microphone Attribute Option shall add the following services to a JAUS component defined by a valid Interoperability Attribute:

Table 4.7-11: Components and Services for Speaker Attribute

| Component (added to) | |
|---|--|
| Service | Reference |
| urn tbd:DigitalAudioSensor, version tbd | AEODRS Common Architecture JAUS Extension Services and Experimental Messages |

In addition, the Microphone Attribute Option shall add the following service to the JAUS component defined by the Platform Management Interoperability Attribute (if there is none, a new component under the Platform JAUS node shall be created). Only a single instance of this service shall be provided – if multiple attributes or attribute options are specified that require it, it shall be treated as the same service for all of them.

Table 4.7-12: Components and Service added to Platform Management Interoperability Attribute

| Component Provided by Platform Manager Attribute (new component if value = none) | |
|--|---|
| Service | Reference |
| urn:jaus:iop:DigitalStreamDiscovery, v0.1 | Custom Services, Messages, and Transports |

4.7.11.3 Notes and Interpretations

See Section 4.4.6 Microphone Interoperability Attribute [Selectable, Multiple] for notes and interpretations.

4.7.11.4 Periodic Messages

See Section 4.4.6 Microphone Interoperability Attribute [Selectable, Multiple] for periodicity requirements.

4.7.12 Lights Attribute Option

The Lights Attribute Option defines the use of an Illumination service alongside the services of a JAUS component that is not dedicated for just lights. For example, an illumination service associated with a Digital Video component indicates that video component has a light source associated with it. On an actual platform, this could be a camera that has a light source associated with it to illuminate the area it is viewing.

4.7.12.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default

- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default (except for Lights attribute)
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.12.2 Component and Service Requirements

The Lights Attribute Option shall add the following services to the JAUS component specified by the Interoperability Attribute the Lights Attribute Option is added to:

Table 4.7-13: Components and Services for Lights Attribute Option

| Component (added to) | |
|--|-----------------------------|
| Service | Reference |
| urn:jaus:jss:ugv:IlluminationService, v0.1 | AS6091 JAUS UGV Service Set |

4.7.12.3 Notes and Interpretations

The following message interpretations apply for the Illumination service (**note that these differ from the Lights Interoperability Attribute**):

Table 4.7-14: Message Interpretations for Lights Attribute Option

| Message(s) | Concept | Interpretations |
|---|--------------------------------|---|
| ID 0513: SetIlluminationState ID 4513: ReportIlluminationState ID 4514: ReportIlluminationConfiguration | IlluminationState bit_field | <ul style="list-style-type: none"> - Headlights – the headlights field shall not be used for a Lights Attribute option. - Left Turn Signal – the left turn signal shall not be used for a Lights Attribute option. - Right Turn Signal – the right turn signal shall not be used for a Lights Attribute option. - Running Lights – the running lights field shall not be used for a Lights Attribute option. - Brake Lights – the brake lights field shall not be used for a Lights Attribute option. - VariableLights – the variable light fields are used to turn on and off lights that have varying intensities, where 0 indicates off and 15 indicates maximum intensity. Values in between shall be mapped to the closest light level the variable light is capable of producing. Up to four variable light sources may be associated with a component using the Lights Attribute Option. As of version 0 of this document, the physical meaning and locations of these variable light sources are not defined. - VisibleLightSource – the VisibleLightSource field shall be used to turn on and off a visible light source on the component the Lights Attribute Option is used with. - IRLightSource – the IRLightSource field will be used to turn on and off an IR light source on the component the Lights Attribute Option is used with |

4.7.12.4 Periodic Messages

There are no special periodic message considerations.

4.7.13 Speaker Attribute Option

The Speaker Attribute Option may be added to any valid Interoperability Attribute Value to have it provide speech/sound/voice capabilities.

4.7.13.1 Valid Attribute Values

- Platform::Basic Platform Manager::Default
- Global::Capability::Default
- Mobility::Remote Control::Default
- Mobility::Teleoperation::Default
- Mobility::Basic Navigation::Default
- Mobility::Leader Follower::Default
- Sensor and Emitter::*::Default (except for Speaker attribute)
- Actuators and Manipulators::*::*
- Communications::Communicator::Default

4.7.13.2 Component and Service Requirements

The Speaker Attribute Option shall add the following services to the JAUS component provided by the Interoperability Attribute it is applied to:

Table 4.7-15: Components and Services for Speaker Attribute Option

| Component | |
|--|--|
| Service | Reference |
| urn tbd:DigitalAudioAnnunciator, version tbd | AEODRS Common Architecture JAUS Extension Services and Experimental Messages |

4.7.13.3 Notes and Interpretations

See Section 4.4.8.2 Notes and Interpretations of Section 4.4.8 Speaker Interoperability Attribute [Selectable] for notes and interpretations.

4.7.13.4 Periodic Messages

There are no special periodicity requirements for the Speaker Attribute Option.

4.7.14 Health Reporter Attribute Option

While not required for IOP V0 implementation, the Health Reporter Attribute Option defines a Health Reporter service that is used to perform built-in test (BIT) operations at Power-On and subsets of built-in-test in the background during runtime (RBIT) and when requested via command message (CBIT). The Health Reporter service maintains a record of the most current BIT results, and provides the most current BIT results when requested by a client or configured event.

When the Health Reporter Attribute Option is specified for a JAUS component, that JAUS component shall provide a Health Reporter service that collects and reports on component health information. The Health Reporter services on the JAUS components shall be used by

the Health Monitor service on the Platform Manager JAUS component to collect health status information for each component and/or service on a JAUS node.

4.7.14.1 Valid Attribute Values

- All attributes that provide a component

4.7.14.2 Component and Service Requirements

The Health Reporter Attribute Option shall add the following services to the JAUS component provided by the Interoperability Attribute the option is added to:

Table 4.7-16: Components and Services for Health Reporter Attribute Option

| Component | | |
|------------------------------------|---------|---|
| | Service | Reference |
| urn:jaus:iop:health:HealthReporter | | Custom Services, Messages, and Transports |

4.7.14.3 Notes and Interpretations

The Health Reporter Attribute Option is a place holder in this version of IOP – currently no advanced health reporting capabilities are defined.

4.7.14.4 Periodicity

There are no special periodicity requirements for the Health Reporter Attribute Option.

5 Appendix A – Interoperability Attributes, Attribute Options, and Parameter Listing

| Core Interoperability Attributes (Core::***) | | | |
|---|-------------------------------|-----------------------------------|--|
| Attribute | Modifiers | Values | Parameters |
| Core Services | Mandatory | Default | |
| Access Control | Mandatory | Default | |
| ID Assignment | Mandatory, Mutually Exclusive | Static Centralized IP-Based | |
| Transport | Mandatory, Mutually Exclusive | JUDP JTCP Custom | Broadcast Type (default = multicast) |
| | | | Multicast Address (default = as specified in AS5669A) |
| | | | IP Address Assignment List Method (default = none) |
| Component Liveness | Mandatory | Default | |

| Platform Interoperability Attributes (Platform::***) | | | |
|---|-------------------------------|---------------------------|-------------------|
| Attribute | Modifiers | Values | Parameters |
| Platform Management | Mandatory, Mutually Exclusive | Basic Platform Manager | |
| | | Advanced Platform Manager | |
| | | None | |

| Mobility Interoperability Attributes (Mobility::***) | | | |
|---|------------------|---------------|---|
| Attribute | Modifiers | Values | Parameters |
| Core Mobility | Mandatory | Default | |
| Drive Timeout | Mandatory | Default | Drive Timeout (default = 1 second) |
| | | | Drive Frequency (default = none) |
| | | | Drive Recovery Time (default = 1 second) |
| Safety Requirements | Mandatory | Default | |
| Remote Control (RC) | Selectable | Default | |
| Teleoperation (Teleop) | Selectable | Default | |
| Basic Navigation (BN) | Selectable | Local | |
| | | Global | |
| Leader Follower (LF) | Selectable | Default | |
| Mobility Limits | Selectable | Default | |
| Velocity State Driver | Selectable | Default | |

| Mobility Attribute Options (Mobility::***) | |
|---|--|
| Attribute Option | Valid Attribute Values |
| Velocity State Driver | Mobility::RC::Default Mobility::Teleop::Default |
| Gear | Mobility::RC::Default Mobility::Teleop::Default |

| Sensor and Emitter Interoperability Attributes (Sensor and Emitter::***) |
|---|
|---|

Unclassified

| Attribute | Modifiers | Parameters | Values |
|-----------------------|--------------------------------|------------|---|
| Digital Video | Selectable, Multiple | Default | |
| Still Image | Selectable, Multiple | Default | |
| Range Finder | Selectable, Multiple | Default | |
| Analog Video | Selectable, Multiple | Default | |
| Pan Tilt Video Sensor | Composed, Selectable, Multiple | Default | Composition (default = Digital Video sensor attribute, Basic Pan Tilt Manipulator attribute with no attribute options added) |
| Microphone | Selectable, Multiple | Default | |
| Lights | Selectable | Default | |
| Speaker Attribute | Selectable, Multiple | Default | |

| Actuator and Manipulator Interoperability Attributes (Actuator and Manipulator:::*) | | | |
|---|----------------------|---------|---|
| Attribute | Modifiers | Values | Parameters |
| General Actuator Requirements | Mandatory | Default | Drive Timeout (default = 1 second) |
| | | | Drive Frequency (default = none) |
| | | | Drive Recovery Time (default = 1 second) |
| Basic Manipulator | Selectable, Multiple | Default | |
| Basic Pan Tilt Manipulator | Selectable, Multiple | Default | |
| Telescoping Mast | Selectable, Multiple | Default | |

| Actuator and Manipulator Attribute Options (Actuator and Manipulator::*) | |
|--|---|
| Attribute Option | Valid Attribute Values |
| Advanced Manipulator | Actuators and Manipulators::Basic Manipulator::Default |
| Pan Tilt Manipulator Position Control | Actuators and Manipulators::Basic Pan Tilt Manipulator::Default |
| Pan Tilt Manipulator Velocity Control | Actuators and Manipulators::Basic Pan Tilt Manipulator::Default |
| Pan Tilt Manipulator Velocity Sensor | Actuators and Manipulators::Basic Pan Tilt Manipulator::Default |
| Pan Tilt Manipulator Position Sensor | Actuators and Manipulators::Basic Pan Tilt Manipulator::Default |
| Manipulator Joint Velocity Control | Actuators and Manipulators::Basic Manipulator::Default Actuators and Manipulators::Telescoping Mast::Default |
| Manipulator Joint Position Control | Actuators and Manipulators::Basic Manipulator::Default Actuators and Manipulators::Telescoping Mast::Default |
| Manipulator Joint Velocity Sensor | Actuators and Manipulators::Basic Manipulator::Default Actuators and Manipulators::Telescoping Mast::Default |
| Manipulator Joint Position Sensor | Actuators and Manipulators::Basic Manipulator::Default Actuators and Manipulators::Telescoping Mast::Default |
| Manipulator End Effector Velocity Control | Actuators and Manipulators::Basic Manipulator::Default |
| Manipulator End Effector Velocity State Sensor | Actuators and Manipulators::Basic Manipulator::Default |
| Basic End Effector | Actuators and Manipulators::Basic Manipulator::Default |

| Communications Interoperability Attributes (Communications::*:*) | | | |
|--|------------------------|------------|--------|
| Attribute | Modifiers | Parameters | Values |
| Communicator | [Selectable, Multiple] | Default | |

Unclassified

| Global Interoperability Attributes (Global::***) | | | |
|--|----------------------------------|---------|---|
| Attribute | Modifiers | Values | Parameters |
| Node | Selectable, Multiple, Aggregator | Default | Name (Default = none) |
| | | | ID (Default = none) – JAUS ID assigned |
| | | | Aggregated Attributes (Default = none) |
| Capability | Selectable, Multiple, Composed | Default | Attribute List (Default = none) |
| | | | Attribute Option List (Default = none) |
| | | | Name (Default = none) |

| Global Attribute Options | | |
|------------------------------|--|-------------------------------------|
| Attribute Option | Valid Attribute Values | Parameters |
| Global Position and Attitude | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*:Default Actuators and Manipulators::*: Communications::Communicator::Default | Report Rate (Default = 1 Hz) |
| Local Position and Attitude | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*:Default Actuators and Manipulators::*: Communications::Communicator::Default | Report Rate (Default = 1 Hz) |
| Acceleration State Sensor | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*:Default Actuators and Manipulators::*: Communications::Communicator::Default | |
| Velocity State Sensor | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*:Default Actuators and Manipulators::*: Communications::Communicator::Default | |
| Digital Video | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default | |

Unclassified

| | | |
|--------------|--|--|
| | Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*::Default (except for Digital Video attribute) Actuators and Manipulators::*:* Communications::Communicator::Default | |
| Still Image | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*::Default (except for Still Image attribute) Actuators and Manipulators::*:* Communications::Communicator::Default | |
| Range Finder | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*::Default (except for Range Finder attribute) Actuators and Manipulators::*:* Communications::Communicator::Default | |
| Analog Video | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*::Default (except for Analog Video attribute) Actuators and Manipulators::*:* Communications::Communicator::Default | |
| Microphone | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*::Default (except for Microphone attribute) Actuators and Manipulators::*:* Communications::Communicator::Default | |
| Lights | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*::Default (except for Lights attribute) Actuators and Manipulators::*:* | |

Unclassified

| | | |
|-----------------|--|--|
| | Communications::Communicator::Default | |
| Speaker | Platform::Basic Platform Manager::Default Global::Capability::Default Mobility::Remote Control::Default Mobility::Teleoperation::Default Mobility::Basic Navigation::Default Mobility::Leader Follower::Default Sensor and Emitter::*::Default (except for Speaker attribute) Actuators and Manipulators::*::* Communications::Communicator::Default | |
| Health Reporter | All attributes that provide a component | |